Bell Laboratories RECORD

Volume XXXV

Number 5

May 1957

Bell Laboratories RECORD

CONTENTS

THE COVER: The flower and ribbon-like cover design is actually a photomicrograph under polarized light of magnetic domain patterns in manganese bismuth (magnification approximately 1000 diameters). For story on magnetography, see page 175.

The BELL LABORATORIES RECORD is published monthly by Bell Telephone Laboratories, Incorporated, 463 West Street, New York 14, N. Y., M. J. KELLY, President; M. B. LONG, Secretary and Treasurer. Subscriptions: $2.00 per year; Foreign, $2.60 per year. Checks should be made payable to Bell Laboratories Record and addressed to the Circulation Manager. Printed in U. S. A.

A Metallurgist's View of Metallurgy

EARLE E. SCHUMACHER
Metallurgical Research

A modern metallurgy department serving a communications organization must keep pace with advances in both metals science and communications technology. From the precise measurement of elusive physical and electrical properties to the formulation of specific alloys tailored to meet rigid design specifications, the metallurgist's skills must embrace a variety of techniques and fundamental processes. At the Laboratories, the Metallurgy Department is directly concerned with all phases of metallurgical research and development from materials testing to fundamental studies of the solid state.

The Bell System is built on metal – in the vast conductor systems spanning the country, in the switching apparatus in central offices, in the telephone in the customer's home and in thousands of miles of submarine cable. Last year, over half a billion pounds of metal were added to the Bell System plant.

The required quantities of some metals are enormous: in 1956 the Bell System used over 200,000,000 pounds each of copper and steel, around 100,000,000 pounds of lead, and masses of zinc, aluminum, nickel and tin. These and other metals, from the less common to the truly rare, provide the conductors, magnets, resistors, capacitors, springs, frames, even the just plain hardware of the telephone plant. For each application a metal must be selected, and this is a responsibility of the Laboratories Metallurgical Research Department.

The metallurgist in this view is primarily an engineer; that is, he is both technologist and economist. He is well grounded not only in the physical and mechanical properties of materials possible for an application, but intimate as well with quantity required, availability, fabrication methods, market conditions and cost, government regulations; and use of the device itself, its life expectancy, and its service environment. To hold to this view of the metallurgist's function, however, is to over-simplify his role in the face of the advancement of communications technology.

The metallurgist has long been a scientist – part physicist, part chemist, part crystallographer. Nevertheless, until recently much of the basic science of metals has been purely descriptive; the knowledge of relations between processing and properties has been empirical. Now, modern physics has

advanced understanding of the solid state to the point where the metallurgist will relate properties of the processed material to its atomic and microstructural state. It becomes possible to predict and control properties by manipulating composition and treatment. The same advances in physics have rendered communications technology more complex, particularly with the introduction of solid-state devices such as the transistor. The Metallurgical Research Department must develop, control and recommend the material not only for such items as capacitor mounting brackets but also for transistors, computer memory devices and solid-state microwave devices.

About half of the program for the Laboratories Metallurgical Research Department originates from the intensely specialized nature of Bell System requirements. The commercial metal producer quite simply cannot afford to undertake the research and development necessary to such specialized application. Nor can we, the System, in general afford to undertake the necessary education of producers in our metals needs. Moreover, it is essential that metals research and device research proceed intimately integrated – indeed, to the point of indistinction between whether a new material creates a device, or a new device gives conception to the required material. Herein lies the origin of the remaining half of the Metallurgical Research Department program, and the origin of its activities at the fundamental research level.

The interplay between technology and basic research is illustrated by our use of nickel – a metal in critically short supply. Through a team approach to alloy development, which typically has included the active participation and strenuous efforts of the Western Electric Co., we have been able to reduce our demand for nickel substantially. It is estimated that our consumption would be more than twice the present rate if it were not for the technological advances and substitutions which have been made. Furthermore, this reduction has been effected not only without jeopardizing the quality of communication but while steadily improving it.

Behind the reduction in requirements for critical nickel through substitutions is a vast accumulation of fundamental knowledge about the properties of materials and their processing – much of it acquired by the Laboratories research teams. The origin and control of fundamental properties such as electrical and thermal conductivity, magnetism, fatigue, yield strength, creep strength and hardness are continuing research efforts. These properties

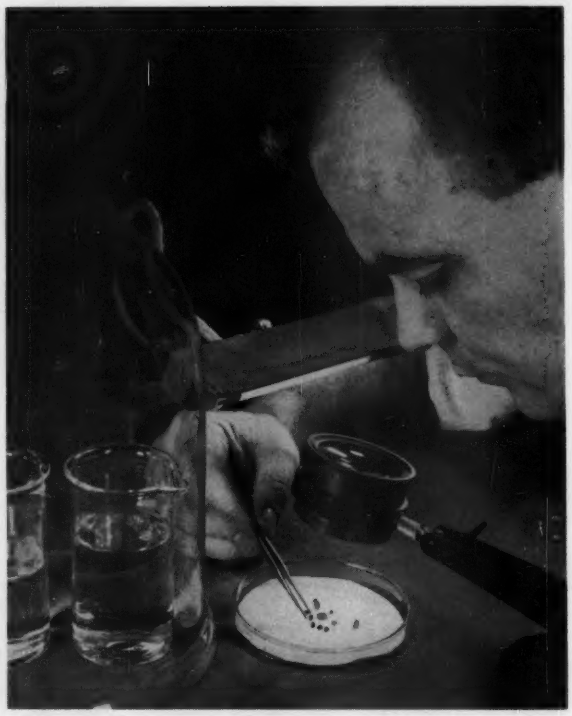


Fig. 1 — L. G. Van Uitert inspects crystals of a new kind of paramagnetic material.

are the consequence of the metal structure and composition. The metallurgist therefore carries out fundamental studies to discover how, by properly combining atoms, the desired properties can be obtained or modified. Some examples taken from current metallurgical research projects may help to show the diversity of our studies, from "practical" to fundamental, as well as their common response to the challenge to increase our control of the properties of metals and alloys.

The mechanical properties of a metal are simply the strength properties significant to mechanical service – tensile, yield and creep strengths and endurance to fatigue. New apparatus designs and life requirement increases have necessitated re-examination of these mechanical properties. The change from manual to machine switching, for example, required the use of spring materials with better fatigue life than brass. The fatigue properties of phosphor bronze or nickel silver would meet these life requirements. However, the restrictions on the use of tin and nickel imposed during and since the war dictated the use of materials which contain less nickel or tin. Metallurgical studies showed that by better control over composition limits, fabrication to obtain fine grain size, and control of residual

stresses, improved fatigue strengths could be obtained with alloys of lower tin or nickel content.

Problems come with progress. Flat springs used in the older types of telephone relay gave service performances which could be predicted accurately on the basis of fatigue tests carried through one hundred million stress cycles; a proposed material could be fully evaluated in about six weeks. The relays employed in automatic message accounting equipment (AMA), on the other hand, must operate into the billions of cycles without failure. To evaluate a material properly on the basis of a billion test cycles would require about fifteen months; on the basis of ten billion test cycles, eleven to twelve years. By invoking the aid of the powerful statistical methods developed for quality control, however, it is now possible by extrapolation to obtain the required accuracy of prediction from feasible tests on a more limited basis – the effects of all variables of material and test machine being under statistical control. The metallurgy group is thus implemented by the resources of modern mathematics, and rather abstract mathematical research is applied to a very practical engineering problem.

Another practical area of metallurgical study concerns the investigation of the properties and applications of solders. Literally billions of soldered connections are made each year, and thousands of tons of solder are consumed in the Bell System. No more than one faulty joint in 50,000 is the desired quality goal; even one such bad joint could cause a serious circuit failure.

The development of solder alloys and improved soldering methods are a major activity. Solders containing much less tin than the alloys presently used may be required in any future period of tin scarcity, and hence the effects of other elements and new compositions are constantly being evaluated. The solderability of metallic parts is an elusive property that is difficult to define. But it is of vital importance in mass soldering methods and it can now be determined readily. A test in which the samples are dipped in molten solder will establish the relative ease with which the metal surfaces will be wet by the solder. A spread test or a capillary rise test can also be used to evaluate numerically the effects of solders, fluxes and metal surfaces. This ability to assign a parameter that weighs so many variables has provided invaluable insurance against the expensive hazard of unreliable joints.

Creep strength is another property of metals that is affected by so many variables that its evaluation is essentially statistical. Creep is the slow deformation of a material under a stress far less than that needed to produce immediate plastic flow; it is the bane of the cable engineer. Creep studies necessitated by the pressurizing of paper insulated cables, to preserve the dielectric properties of the insulator, have led to the development of lead alloys having improved creep characteristics for use in the sleeves which cover cable splices. The introduction of composite cable designs and aluminum cable sheath has required the development of new testing techniques to evaluate the probable service life of the new designs.

In the evolution of aluminum cable sheath we perceive the links among technology, development and research. It has been known for many years that aluminum would offer advantages in strength, weight and cost over lead alloys as a cable sheathing material. In Germany before the war, short lengths of aluminum sheath had been extruded over paper insulated cores. The temperatures required, however, were such that the paper was badly scorched when the presses were stopped for recharging. This made the extrusion of continuous lengths uncommercial.

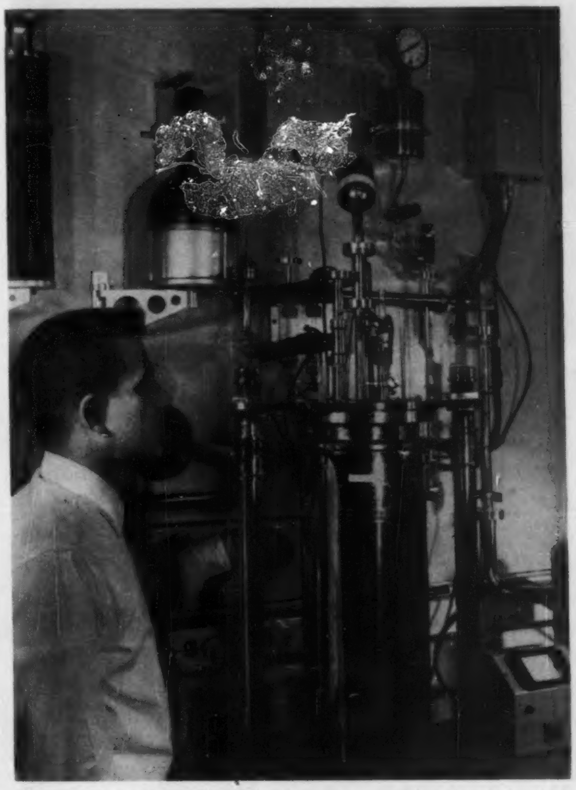


Fig. 2 — S. E. Haszko starts operation of the low temperature calorimeter.

Yet, because of the undoubted attractiveness of aluminum sheath for telephone cables, the subject was explored at the Laboratories. Instead of attempting to modify existing extrusion devices, basic studies were carried out on plasticity and the mechanics of the flow of materials under pressure through cavities and over surfaces. The information thus obtained has been applied to the design of extrusion equipment in which advantage is taken of preferred flow paths to keep pressures at a minimum. Extrusion experiments using this equipment show that die contours are of great importance in determining extrusion pressures and perfection of the sheath.

Fig. 3 — D. F. Gibbons secures test leads for low temperature elasticity measurements.

The plasticity measurements on lead and aluminum indicated that aluminum would require about ten times the pressure normally used for lead alloys in conventional extrusion equipment. However, the new laboratory equipment, based on the exploratory studies, permits the extrusion of aluminum at temperatures that do not scorch paper during recharging and at pressures only about ten per cent higher than those used for lead in conventional equipment. Thus, the feasibility of extruding aluminum sheath commercially was established and the ground cleared for introducing aluminum sheath into the Bell System plant.

A piece of metal is rarely useful until it has undergone some plastic fabrication to alter its shape and properties. Our present basic plasticity studies include a program on the effect of temperature and rate of straining on the flow of metals. Although it has long been known that, at a given state of strain, the yield stress of a metal depends on the temperature and on the rate at which the metal was previously deformed to the state of interest, only a few investigations had previously been conducted in this field of activity.

Early experimental data from our fundamental program now indicate that a unique relation exists between the plastic behavior of metal and its yield stress. Two specimens of the same metal deformed in different ways to a state of the same yield stress appear to exhibit the same rate of work hardening. As temperatures change they should have the same increase or decrease of the yield stress. The establishment of this observation as a general relation will be of considerable importance to the formulation of the fundamental theory of plasticity. This is basic metallurgical research.

It now appears that many properties, in particular mechanical properties, depend mostly upon the behavior of atomic-scale defects that ordinarily occur in metal and alloy structures. These defects include dislocations, vacant atom sites, interstitial atoms and impurity atoms. An attack is being made on the dual problems of how these defects act and interact, and of finding means to control their behavior. A new means to achieve such control and to conduct basic experiments on the properties of defects is now available in high intensity beta particle and neutron bombardment in modern accelerators and nuclear reactors.

In an important part of this program on imperfections in metals, currently in progress, ultrasonic acoustic waves are being used to detect and study the motion of dislocations. Clean, uncomplicated experiments are possible in which acoustic shear waves of appropriate frequency are sent into a relatively perfect metal crystal. Dislocations in the structure of the crystal may be set into vibration by these waves, thereby absorbing and dissipating some of the acoustic energy. The observed attenuation is thus related to the nature of the dislocations present and to the ease with which they can move about in the structure. This method serves to identify the structural perturbations which aid or oppose such motion.

Another aspect of the program on plasticity makes use of the recent finding that germanium and silicon, usually thought of as brittle, can be plastically deformed. We have deformed these diamond-like semi-metals in tension and compression by achieving the appropriate conditions, and we have discovered two unusual characteristics of these materials which make them particularly valuable in the study of defects. First, the position of dislocations in these crystals can be revealed in the form of etch pits on specially prepared surfaces. Second, the presence of both vacancies and interstitial atoms can be detected through their effects on electrical conductivity. Studies of these etch pits have given experimental confirmation to much of the dislocation theory of plasticity. Conductivity studies have also confirmed the predicted formation of vacancies and interstitial atoms during plastic deformation and therefore hold promise of spelling out on the atomic scale the closely related mechanism of how metals are hardened by deformation.

A fourth attack on plasticity problems is being made through studies of the metal whiskers found growing spontaneously on metal surfaces. These whiskers may often be so free from lattice defects that they do not show plastic behavior of the ordinary kind. They therefore remain elastic at stresses which are orders of magnitude larger than the usual yield strength levels observed in ordinary specimens of the same metal. Metallurgists are learning the conditions under which such defect-free structures can be grown and are producing specimens of many materials with these unusual mechanical properties.

The role of defects in altering the electrical properties of semi-conductors is as important to the use of these materials in solid-state electronic devices as it is to research in plasticity. Bell Laboratories metallurgists have pioneered in the preparation of semiconductors such as silicon and germanium — first, for crystal detectors used in radar and microwave relay, and later, for research culminating in the transistor, the silicon solar battery and the solid-state diode. They have prepared the purest germanium and silicon known to man, containing less than one part of harmful impurity in ten-billion of the semi-conductor. The techniques of zone melting used to purify these materials have been widely adopted by the semiconductor industry and have been extended to other semiconductors, to metals and to chemicals.

The program now in progress involves the preparation of extremely pure metals and a study of their physical properties. This includes a fundamental study of the preparation of pure and perfect single crystals of various metals, so that their properties can be investigated without the complicating effects of grain boundaries, impurities, dislocations, lattice vacancies and the like. In these respects the pure single crystals command the same interest as the apparently unrelated metal whiskers. It is expected that these studies will be extended to the rare metals, such as scandium, yttrium, and the rare earths only recently made available in elemental form. Properties here are almost completely unknown; there is opportunity for exploration in virgin territory.

Fig. 4 — P. H. Schmitt removes the mold from the high vacuum furnace.

Metallurgical concern with magnetic properties antedates by many years any equal interest in semiconductors or rare metals. The Bell System needs superior magnetic materials to make possible the tenfold or more reduction in size required for miniaturized equipment, and to provide the more powerful permanent magnets essential to the development of more and more efficient devices. Perhaps we ought to consider the permanent magnet as the prototype solid-state electronic device. Theory has told us that magnets made of very fine particles, each consisting of a single magnetic do-

main, should have very good permanent magnet qualities. Ways to make better magnets of oriented assemblies of such particles are constantly under development. Among the materials being studied are iron, manganese bismuthide and barium-iron oxides (Ferroxdur). Effects of particle shape, size and internal structure are being revealed and valuable fabrication experience is being acquired.

The development of the mineral-like magnetic materials known as *ferrites* is one of our chief concerns. These materials, made from compounds of iron oxide in combination with other oxides, have remarkable magnetic properties and are widely used throughout the Bell System. It is instructive to contemplate an historic paradox here. Man's acquaintance with magnets began with the ancient lodestone, a natural ferrite. After centuries of study, a revolution in physics, and millions of dollars invested in research, we are now looking with new perspectives at similar structures of which lodestone is a prototype.

Metallurgists have now learned enough about ferrites to custom-design compositions and treatments that will meet many pre-set specifications. An example is the ferrite core material for inductors in modern communication equipment. The trend has been toward ever higher carrier frequencies so that more information can be transmitted in a given communication channel. A serious limitation on this development has long been losses, particularly eddy current losses in inductors, that increase rapidly with frequency and cause severe attenuation. The development of ferrite cores, designed to have good magnetic properties but with extremely low electrical conductivity, has significantly reduced these losses and made possible a large extension of operating frequencies.

Another quite important application of these materials is for the isolators needed in microwave transmission systems. Such devices may be used to act as a one-way valve which, by isolating oscillator from antenna, permit a signal to pass toward the antenna, but prevent reflected waves from perturbing the oscillator. Large gains in efficiency result. The frequency at which these devices operate is now controllable through small changes in composition of ferrites.

A promising application of ferrites is for "square-loop" materials, designed to have essentially square hysteresis loops. The magnetization of these materials remains constant in direction and strength until a sufficient reverse field is applied. Then a sudden complete reversal of magnetization occurs.

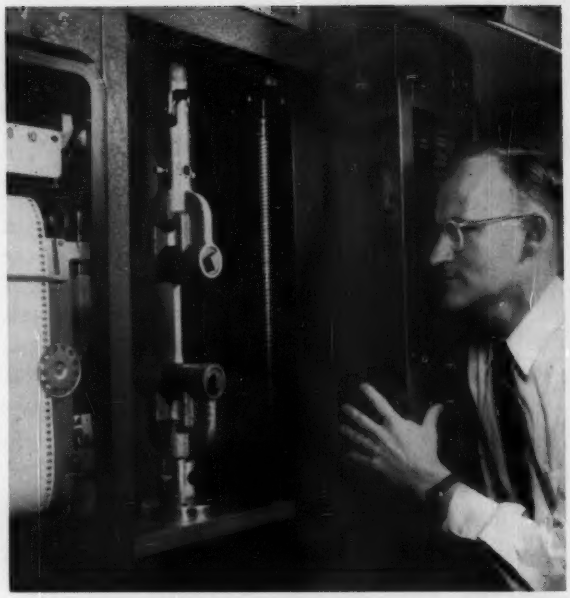


Fig. 5 — R. R. Hart observes a tensile test in progress in the automatic Instron testing machine.

These "yes" or "no" directions of magnetization can be used much as relays are used to store information, but with the great advantage of requiring no moving parts. Devices based on this principle are potentially of great value for use in computers, magnetic storage and switching applications.

The current trend in fundamental metallurgical research toward convergence with solid-state physics is exemplified by the types of physical measurement we are now obliged to make, and in the laboratory facilities required by an active group. Thus, the observation of physical and mechanical phonomena at low temperatures, approaching absolute zero, has been generally neglected by metallurgists until fairly recently. For a number of years, however, the Metallurgical Research Department has had in operation a liquid helium cryostat, which has been used for studying metals, ferrites, and semiconductors by acoustical methods at extremely low temperatures. Recently, a new laboratory has also been established for additional calorimetric and cryogenic measurements. These new facilities will permit us to make precise measurements of heat capacities and other thermodynamic quantities over temperatures ranging from near absolute zero to several hundred degrees above room temperature. The information obtained will add significantly to our knowledge of phase equilibria in solids as well as to our understanding of interatomic forces and modes of thermal vibration in solids.

The new laboratory is also engaged in studies of transport phenomena at very low temperatures. The idea behind this work is that, at these temperatures, scattering of charge carriers by thermal vibration of the atoms is insignificant compared to scatter by atomic defects of the type referred to previously. In this way, extremely small effects of impurity atoms, vacancies and interstitial atoms can be studied. The phenomena under investigation are electrical conductivity, Hall effect in ultrapure material, the Nernst effect and the thermoelectric effect. Measurements of electrical conductivity of metals are so precise that they reveal the presence of trace impurities in amounts less than can be detected by other sensitive means such as the spectroscope.

Despite the compelling interest and deep significance of this work it does not mean that metallurgy will become a subdivision of solid state physics. It does mean, however, that fundamental research in metallurgy must proceed with the pace and intensity of that in sister sciences. This is essential if the metallurgical function of providing the metallic materials for the device-products of modern thought is to be fulfilled. However complex his laboratory tools and abstract his intellectual tools, the metallurgist will always be first and finally concerned with the product of furnace and rolling mill. The view of a Laboratories metallurgist must embrace all phases of metallurgy, fundamental as well as practical, to envisage the means of introducing new developments into practice so that the Bell System may have products essential to its continuing growth.

THE AUTHOR

E. E. Schumacher received the B.S. degree from the University of Michigan and the degree of D. Eng. from the South Dakota School of Mines. Throughout Dr. Schumacher's thirty-nine years with the company he has been concerned with studies pertaining to metals. He helped organize the Department of which he is now Director. Dr. Schumacher is the author of numerous papers on metallurgical subjects and has taken active part in the affairs of the technical societies, including the American Institute of Mining and Metallurgical Engineers and the British Institute of Metals. He is a past director of the American Institute of Mining and Metallurgical Engineers and a past chairman of its Institute of Metals Division. In 1950 Dr. Schumacher delivered the Annual Lecture of the Institute of Metals Division of the A.I.M.E. and the Autumn Lecture of the British Institute of Metals in Bournemouth, England. During World War II he served on various boards of the National Defense Research Committee and was a member of the Metallurgy panel of the NDRC.

Radio-Relay Routes in Virginia and North Carolina

The Long Lines Department of the A. T. & T. Co. is planning a new TD-2 radio-relay route from Aylett, Virginia, to Rocky Mount, North Carolina. The new route will connect at the Virginia end with the north-south express route. Initially, there will be two channels in each direction, one for telephone service and one for protection. Application has been made to the FCC for permits.

Another TD-2 route, also in the planning stage by Long Lines, will run westward from Aylett to connect with the Washington-Atlanta route. Long Lines has applied for construction permits and plans an initial three channels in each direction, two for telephone service and one for protection. In addition, an existing TD-2 route will be connected to this new facility to provide through circuits between Roanoke, Virginia, and northern points.

One of the most important of Laboratories postwar transmission systems developments, radio relay was first used on an extensive experimental scale in a New York to Boston field-trial beginning in November of 1947. This system consisted of seven intermediate radio-relay stations and was used with coaxial cable from Washington, D. C., to New York to provide the longest television network to that time, a distance of about 500 miles. Today, radio-relay systems, along with coaxial cable systems, criss-cross the nation to bring long-distance telephone and television service to most of the people of the United States.

A Remote Line Concentrator for No. 5 Crossbar

G. E. FESSLER *Switching Engineering*

The high cost of customer cable plant naturally leads to the thought of concentrating telephone traffic onto a few cable pairs. This is especially true where groups of customers are located some distance from the central office. Such an arrangement has been made economically feasible by the development of transistors, semiconductor diodes, and other miniature electronic apparatus. Field trials of concentrating equipment have given valuable information as to traffic loads, calling rates, and performance in actual service. As a result, a standard line concentrator is now being developed for the No. 5 crossbar system.

An average 10,000-line No. 5 crossbar central office may have in excess of $1,000,000 invested in customer loop outside plant – the cables or open wires that connect individual customers to the office. This amounts to an average investment in loop plant of slightly over $100 per line. In addition to the first cost, rather sizable annual charges are incurred for upkeep. In recent years, periodic copper shortages and the vast Bell System expansion program have presented difficulties in meeting cable demands. The cost of copper has also been increasing steadily. These factors highlight the desirability of reducing the amount of cable required by substituting less costly facilities.

One method of accomplishing this is the use of concentration techniques to take advantages of the statistical character of telephone traffic. The average telephone customer makes very inefficient use of his line – he uses it only about 5 to 10 per cent of the time during the traffic busy hours. If everyone connected to a 10,000-line switchboard wanted to talk at once, the board would require 5,000 double-ended cords to make the connections. The same would be true of the switching paths required in a dial office. Such a situation would rarely, if ever, occur so switching systems are engineered to handle simultaneous conversations on only about 15 to 20 per cent of the lines. Thus, within the central office, a large number of lines are *concentrated* onto a smaller number of switching paths. Figure 1(a) shows how 49 lines are concentrated onto 10 line links or paths to the junctor switches in the No. 5 crossbar system.

If customer lines could be concentrated onto only a few cable pairs to the central office, fewer pairs would be needed and cable costs would be reduced. Figure 1(b) shows how this could be accomplished. Alternatively, a cable already installed

could serve more customers, as shown in Figure 2. A line concentrator is now under development for use with No. 5 crossbar offices, and shows promise of affording substantial savings and providing greater flexibility for outside plant. The arrangement consists of a remote line concentrator (RLC) mounted on a pole or on a basement wall near a group of customers, and a special concentrator line-link frame in the central office. Application of concentrators to a given situation should permit cable requirements to be reduced as much as 75 per cent.

To be useful, a concentrator must meet two requirements. First, it must provide telephone service comparable both in features and quality to that provided by a non-concentrated line. Second, it must be sufficiently less expensive than cable facilities against which it is competing to yield a demand that justifies its development and manufacture. As the distance between the central office and customer increases, so does the cost of providing cable facilities. Therefore, concentrators will find their main application on the outskirts of the central-office service area where the longest customer loops are needed. Concentrators may also be used to economically extend service areas and, in some instances, avoid the installation of small unattended community dial offices. Such special circumstances as additional conduit required, water crossings, or seasonal traffic conditions may "prove in" concentrators at shorter distances in individual locations.

A typical concentrator application is shown in Figure 2. The problem here is to provide 45 additional lines without adding cable between the housing development and the central office. By using a concentrator as shown, a total of 88 lines are made available. If 48 of the cable pairs were used for concentrator trunks, a theoretical maximum of 199 lines could be served from this point over the existing 51-pair cable to the central office.

The principle of customer line concentration and the incentive to implement it have been with us for a long time. In the past, studies have indicated

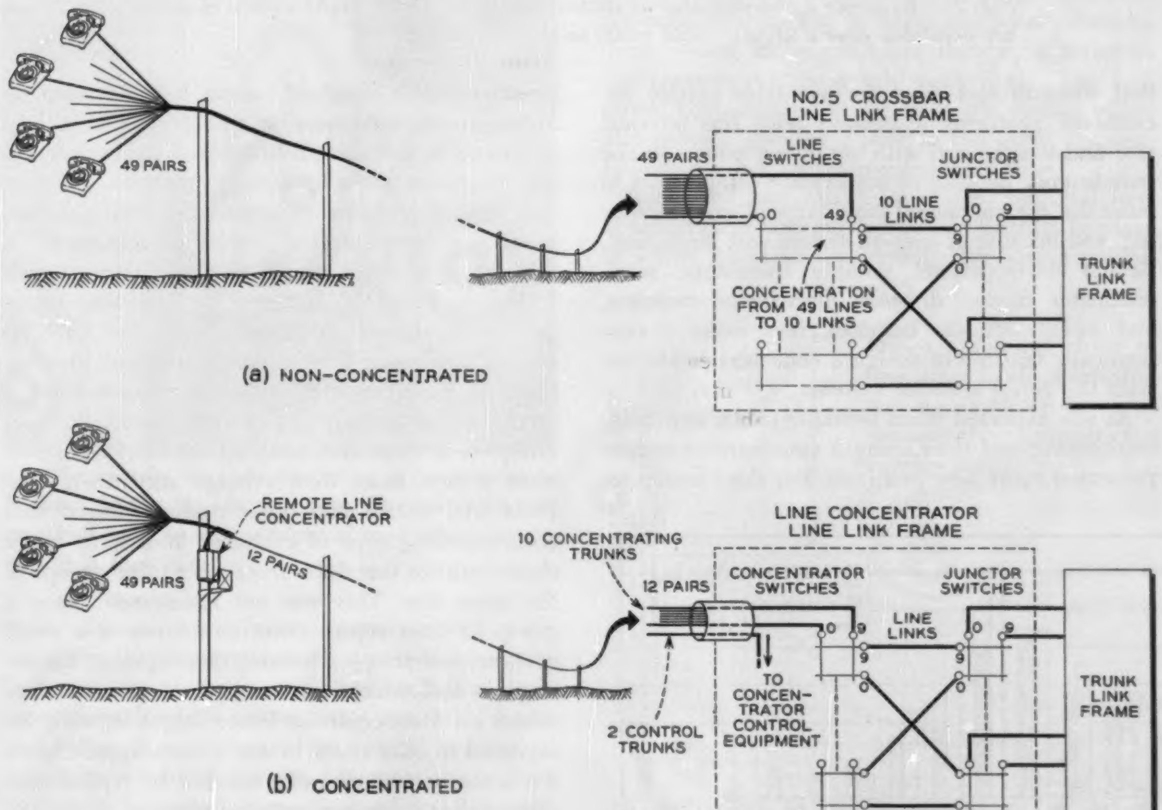


Fig. 1 — (a) Concentration of 49 lines to 10 links is accomplished by the switches of a No. 5 office. (b) With a remote concentrator, pairs become extensions of the links and cable requirements are less.

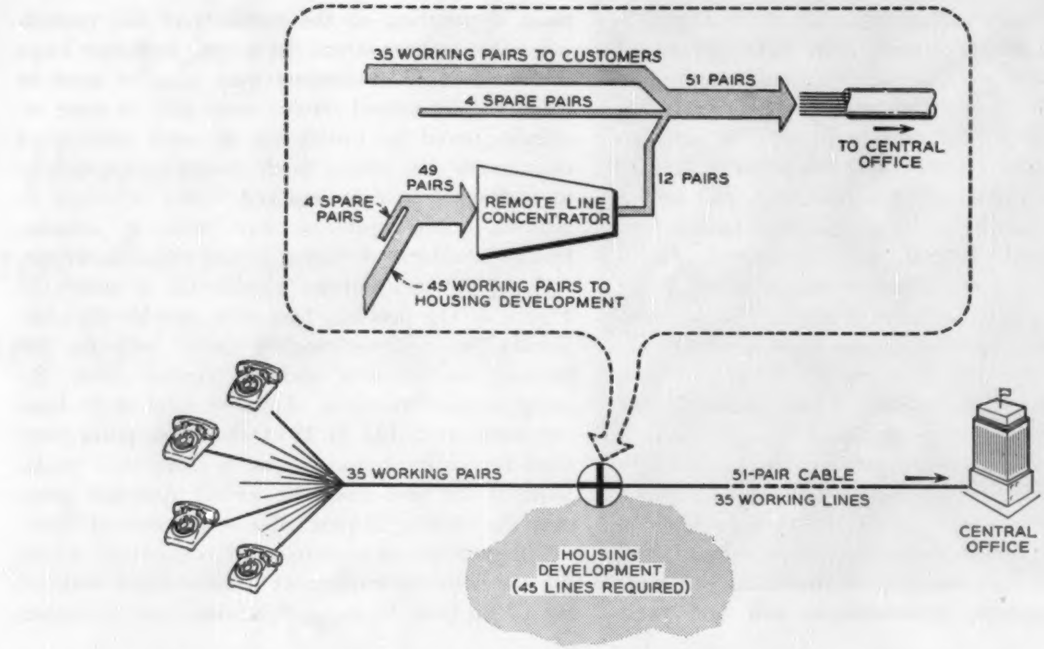


Fig. 2 — By using a concentrator as shown, a total of eighty-eight usable circuits are available over a 51-pair cable route to the central office.

that concentrators were not profitable mainly because of problems associated with the physical size and weight and with supplying power to the remote unit, because of inadequate components to meet the environmental conditions of pole mounting, and because of over-all system cost limitations. Recent developments, notably transistors, semiconductor diodes, dry-reed glass-sealed switches, and nickel-cadmium batteries, now make it economically feasible to design a concentrator for use with the No. 5 crossbar system.

As was expected when breaking into a new field, engineering and developing a concentrator system presented many new problems. For this reason, development of a standard system was preceded by an exploratory engineering and development program and by extensive field trials of the experimental equipment under operating conditions.

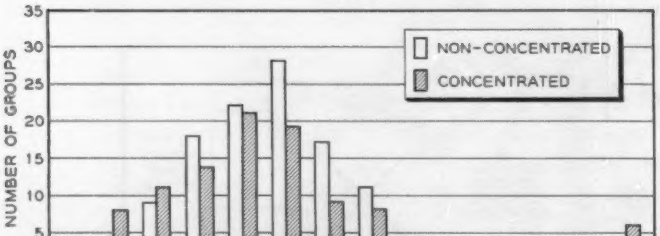


Fig. 3 — Distribution of concentrated and non-concentrated groups compared to average office group of the same size.

A typical problem concerned the traffic characteristics of concentrator groups of customers. A fairly random distribution of customer lines on each line link frame is obtained by selective cross-connecting at the main distribution frame. Each incoming cable pair may be assigned to any line-link frame in the office which offers the proper class of service. This assignment procedure results in most groups of 49 or 50 lines carrying average traffic, with some groups more than average and others less. Field trial results and other studies showed that concentrator groups of customer lines have traffic characteristics that differ from other office groups of the same size. This was not unforeseen, since a group of lines representing customers in a small geographical area – a housing development, for example – and which are assigned to adjacent terminals on a concentrator frame might logically be expected to offer traffic of one general type. Figure 3 is a comparison of traffic handled by typical concentrated and non-concentrated groups.

An important factor in typical concentrator usage is that a small percentage of higher-usage lines yield a disproportionate share of the total group

load, Figure 5. This, of course, suggests the possibility of identifying and removing these high-usage lines, thereby making room for a greater number of low-usage lines. These traffic data and procedures illustrate the need for the new traffic measuring facilities developed for the concentrator system and the need for close traffic administration of the lines connected to the concentrator.

Another problem is determination of a cross-connection terminal and housing arrangement for a concentrator that is suitable for mounting on a pole

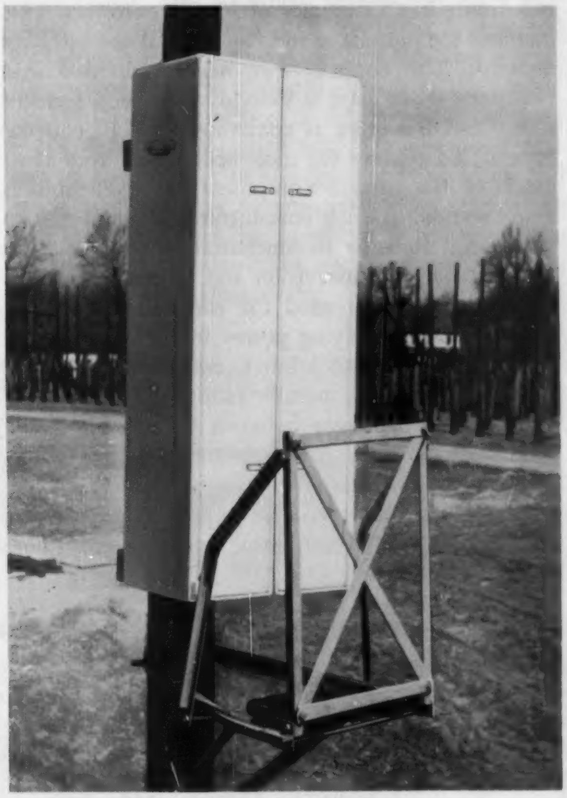


Fig. 4 — Model of pole mounting arrangement to be used in the standard system. Concentrator and terminal box are independent of each other but are mounted together.

or on an apartment-house basement wall while satisfying the requirements of appearance, accessibility for maintenance, and low cost. The early experimental remote concentrator was rather heavy and bulky; it was mounted in a metal housing, as shown in the headpiece, and connections to lines and trunks were made through a modified BD terminal. The version now under development will be considerably smaller and lighter and housing arrangements are expected to contain both concentrator and cross-connection terminal in one dual mounting, Figure 4.

Such a remote unit requires that components be low in cost, physically small and light, low powered, and highly reliable in environmental conditions encountered in pole or basement mounting. Transistors and semiconductor diodes show promise of meeting these objectives for the majority of signaling and control functions. The concentrator crosspoint and control-relay problems were solved by the use of dry-reed glass-sealed switches. A new application of these switches developed for the concentrator is a magnetically-latched relay that operates and releases on oppositely-polarized current pulses and does not require any holding current in either state.

Another problem involves the method of providing power to the concentrator. Even though the use of transistors and similar devices has reduced the average power drain per concentrator to about 5 watts, the peak power needs are much greater and the difficulties involved in economically providing continuous power over the longer distances are considerable. The problem has been solved by using sealed nickel-cadmium storage batteries at the concentrator to supply peak loads. The batteries, kept charged by dc from the central office, also provide standby power in the event the central-office supply is interrupted for a time.

Reliability and maintenance also required new approaches in both procedure and facility. In place of a few relays in the central office and a pair of

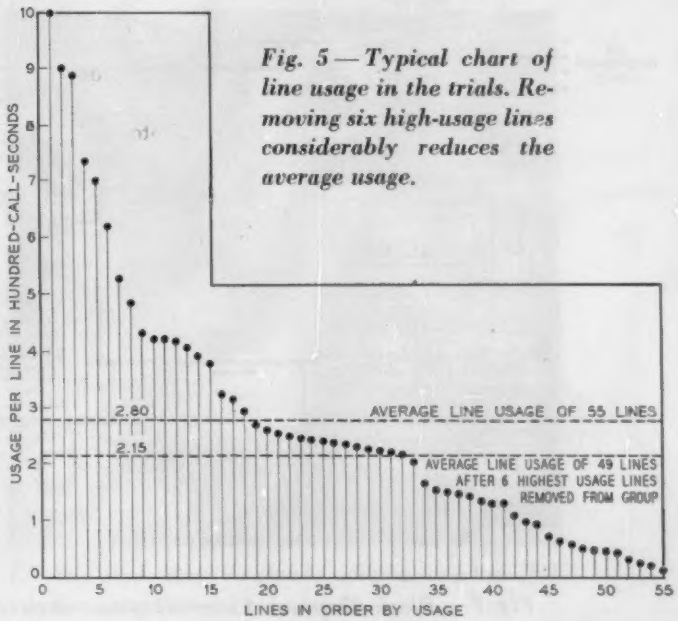


Fig. 5 — Typical chart of line usage in the trials. Removing six high-usage lines considerably reduces the average usage.

Fig. 6 — M. E. Krom points out to the author a feature of a standardized plug-in type printed wiring unit used in the trial equipment.

wires out to the customer's location, the concentrator system utilizes thousands of electronic components on every call, with about half of them located in the remote unit. Highly reliable components and new techniques and procedures show promise of mastering the problems of reliability and maintenance.

The new line concentrator involves extending the 10 line links of the line-link frame out to a location near a group of customers. In effect, it moves the function of the first group of switches out of the office and onto a pole. Concentration of 49 lines to 10 trunks is done at the remote unit, and the trunks then become merely extensions of the line links as shown in Figure 1(b), it was necessary to retain the 10 x 10 switch in place of the line switch for flexibility.

A block diagram of the No. 5 crossbar line concentrator system is illustrated in Figure 7. The central-office portion consists of two bays of equipment. Each concentrator forms one horizontal group having access to 10 links, and each concentrator line-link frame has a capacity of 10 concentrators. This matches the pattern of the No. 5 crossbar switching network. The control equipment is divided into two parts — one part is individual to each concentrator and the other is common to all 10 concentrators. To achieve the most economical system, as much of the control equipment as practicable is made common. Each concentrator is connected to the central office by 10 concentrating trunks for the ringing, dialing, supervision and talking paths and two control trunks used for concentrator control signaling and supplying power to the remote unit. After a connection to a line is established, the concentrator provides a metallic path free from bridges and other appendages between the customer line terminal in the line concentrator and the central office switches. The use of concentrators in exchange plant, therefore, will require no changes in transmission design and cable loading. Each cus-

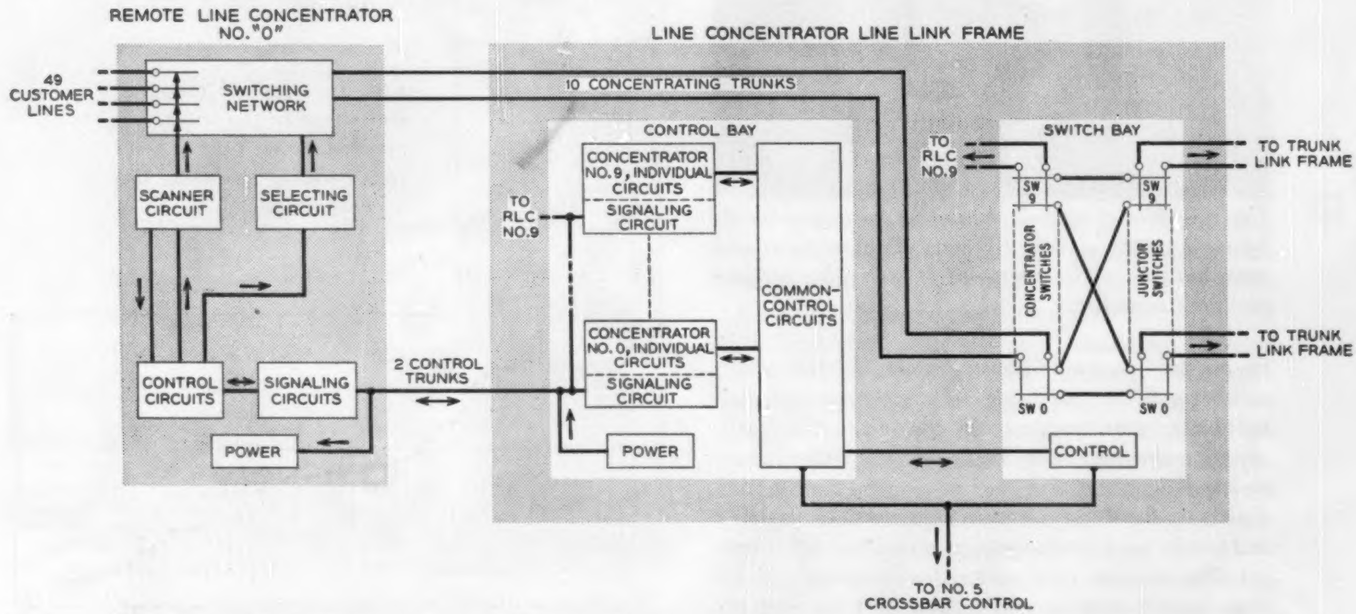


Fig. 7 — Block diagram of over-all system showing one concentrator; system can accommodate ten.

tomer line has access to 6 out of the 10 trunks (links); 4 of the 6 are chosen by a preference arrangement, with 2 being common to all lines as last choices. This is done to decrease the number of relatively expensive crosspoints required in the remote concentrator.

The remote concentrator is a "slave" of the line-link frame — it is controlled and driven, both signalwise and powerwise, from the central office. A train of pulses transmitted to the concentrator via the control trunks causes each line to be sampled or "scanned" four times per second. When a customer originates a call, this condition is detected by the next scan of that particular line and a service-request signal is transmitted back to the central office. The time position of this signal in the scan cycle identifies the calling line. The line-link frame control then selects an idle concentrating trunk and requests the marker to connect it to an originating register. Trunk and line identity transmitted to the remote unit are followed by a train of control pulses that cause the concentrator crosspoints to close.

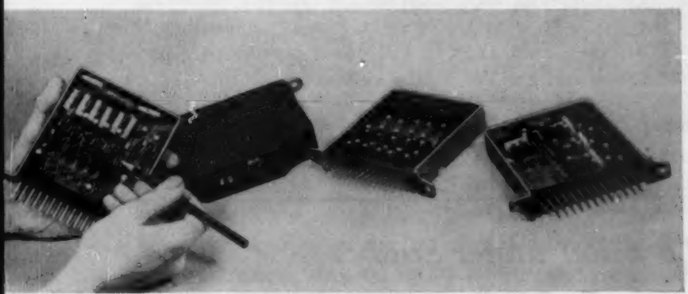


Fig. 8 — Pencil points to transistors in one of the units used in the trial equipment.

The line requesting service, the selected trunk, and an originating register are now interconnected and the customer receives dial tone. Depending on the position in the scanning cycle, the elapsed time from lifting the receiver to the receipt of dial tone is from 260 to 520 milliseconds. After dial tone is established, the concentrator control equipment releases and scanning is resumed. Similar operations are involved in handling calls to the customer from the central office.

Nearly all aspects of the concentrator were new and involved many areas in which little experience was available. Therefore, prior to the engineering and development of a standard system for manufacture, field trials of experimental models were conducted. Over-all objectives of the trials were to determine the feasibility of the electronic concentrator approach, to obtain information on traffic characteristics of concentrator-sized groups of lines, and to demonstrate the traffic-handling adequacy of the concentrator. Other objectives were to gain experience with operation of the new devices and circuits and with the installation, administration, and maintenance of concentrators under actual service conditions.

Experimental equipment used in the trials is shown in Figures 6, 8 and 9. Almost all the concentrator equipment and the line-link frame electronic equipment was plug-and-jack mounted to provide flexibility and ease of maintenance. Each field trial used one remote unit and a line-link adapter frame equipped for one concentrator. The trials were conducted in three different areas — Freeport, Long Island; LaGrange, Illinois; and Englewood, New Jersey. In each area, the concentrators were installed successively in two or three locations but connected to the same central office. Individual concentrator locations were selected to obtain a spread of installation and environmental conditions, outside plant arrangements, and customer groups having different traffic characteristics. The trials also spanned the summer and winter seasons to gain operational experience under both hot and cold weather conditions.

At each location, the number of lines handled by a concentrator was built up rapidly until full traffic load was approached. To provide service for the maximum number of lines, it became necessary to observe traffic for a time to locate the high-usage

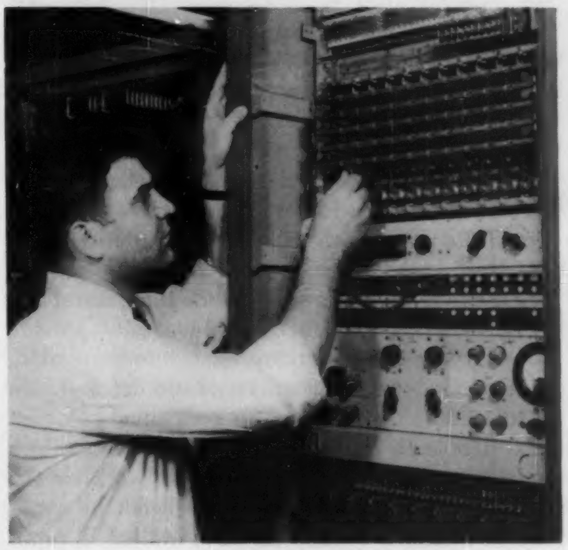


Fig. 9 — A. J. Mustillo checks switches in a line-link adapter frame used in the trials.

lines; these lines were then removed and replaced with a greater number of known low-usage lines or with lines selected at random. The central-office equipment included facilities for measuring and recording traffic usage and dial-tone delay information on magnetic tape. The tapes were sent to the Laboratories for processing to provide information on which to base decisions on the line additions and changes to be made.

Results of the concentrator field trials have been used in the engineering and development of a standard system. The standard equipment will be more reliable, easier to install and use, and the remote unit will be considerably smaller and lighter than the experimental equipment. The line concentrator line-link frame, with a capacity of 10 remote line concentrators, is expected to occupy about two and one-half standard 30-inch bays. The remote unit, with cross-connection facilities, will be compact enough for pole mounting in a manner similar to that illustrated in Figure 5.

In many ways, the No. 5 crossbar line concentrator is a pioneer – the forerunner of many electronic switching facilities of the future.

THE AUTHOR

G. E. Fessler joined the Laboratories in 1949 immediately after receiving the B.E.E. degree from the University of Minnesota. During the three years of his CDT training he was in a systems engineering maintenance group engaged in the development of simplified test facilities for the No. 5 crossbar senders and registers. Following this, he was in charge of a group working on a transistorized system for the military, and since 1954 he has been responsible for the system engineering of the line concentrator for the No. 5 crossbar system. Mr. Fessler, a member of the A.I.E.E., served in the U.S. Navy from 1940 to 1945 as a maintenance and training specialist on communication and gun fire control systems.

Expansion of Holmdel Location under Study

One of the world's leading architectural firms, Eero Saarinen and Associates of Bloomfield Hills, Michigan, has been commissioned to prepare plans for development of the Laboratories' 450-acre site at Holmdel, N. J. Signing of the contract was announced on April 8 by Dr. M. J. Kelly.

The contract calls for an architectural study of an overall site plan which will allow an orderly expansion at Holmdel when future space needs require such a move. This plan will include the general layout of buildings which could eventually provide space for some 4,500 employees.

Included in this study will be a more detailed plan for a building large enough to accommodate about 1,500 people to care for shorter-range needs. The study will require several months of work by the architect. Plans for construction will not be available until after the study has been evaluated, probably sometime early in 1958. If at that time it is decided to proceed with construction, plans for personnel moves will be formulated immediately.

Mr. Saarinen received his B.F.A. degree from Yale in 1934, and was the winner of the Charles O. Matcham Fellowship, which allowed him to spend the next two years traveling in Europe. On his return to this country in 1936, he became a partner with his father, and for more than a decade worked with his father and with other architects. In 1950, Eero Saarinen and Associates was founded.

Eero Saarinen has won several top architectural prizes and is regarded as one of the outstanding creative architects. Among his recent prizes is the Grand Architectural Award from the Boston Arts Festival last spring, for his design of Massachusetts Institute of Technology's cylindrical brick chapel. Mr. Saarinen also designed the 25-building General Motors Technical Center near Detroit. He was visiting critic at Yale in 1951 and at M.I.T. in 1955. He is a member of the American Institute of Architects, and was president of the Detroit Chapter in 1953.

Magnetography

The Microscopy of Magnetism

F. G. FOSTER *Instrumental Analysis*

Various aspects of the broad subject of magnetism have long been the subject of intensive investigation at the Laboratories. One powerful aid in these studies has been a technique which makes it possible to see the actual orientation of poles and domains on the surface of a magnetic material. With this technique, the optical microscope is becoming an increasingly important research tool in studies of magnetism.

Although the phenomena of magnetism have been known for many centuries and their forces applied to practical problems with tremendous advantage, they have defied study by ordinary visual methods. One of the early methods of observing magnetic effects was to sprinkle iron filings above a magnet and allow the filings to orient themselves along the paths of magnetic force. As illustrated in Figure 1, the filings are aligned with the greatest concentration near the poles. It was with this demonstration and the simple compass test that every student of elementary physics encountered the law – "like poles oppose and unlike attract." This method of study, although interesting from the gross viewpoint of the external forces, gave no light on the internal forces that must be present and in equilibrium.

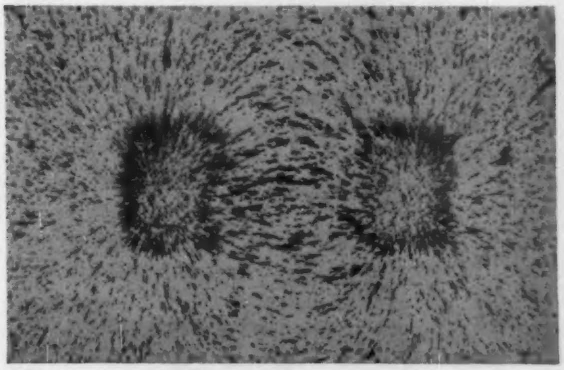


Fig. 1 — Iron filings oriented along the magnetic lines of force around and between the poles of a small horseshoe magnet placed under surface shown.

The first relatively successful attempts toward "seeing" magnetization, or visually appraising the forces that occur in the individual crystal of a ferromagnetic material, were not made until recent years. In 1931-32, Professor Francis Bitter of the Massachusetts Institute of Technology described a method by which it was possible to see the separate so-called "magnetic domains" in a specimen. When a piece of ferromagnetic material is demagnetized, a nearby compass needle will be unaffected, and iron filings sprinkled on the sample will not indicate the presence of magnetic fields. When the sample is examined microscopically, however, it is found to consist of small regions, each of which is magnetized to saturation in a certain direction. These regions are called "magnetic domains".*

In using Bitter's method, which was later used and greatly improved by W. C. Elmore of Swarthmore College, and L. W. McKeehan, formerly of Bell Telephone Laboratories, a suspension of colloidal magnetite is employed. This is an extremely fine iron oxide in a soap solution. When a drop of the colloidal suspension is placed on a freshly polished magnetic surface and covered with a thin glass disc, the magnetic particles are attracted by the strong flux at the domain boundaries. A metal-

* RECORD, *October*, 1952, *page* 385.

Fig. 2 — Magnetic domain patterns obtained on silicon iron by H. J. Williams using the colloidal magnetite method with darkfield illumination.

lurgical microscope which magnifies about 100-200 diameters is used to see the outlined domains, and the specimen is studied with either "brightfield" or "darkfield" illumination.

In the brightfield system, the light rays from the source are directed through the microscope objective lens to illuminate the specimen. On return, the reflected light from the specimen passes through the objective lens, thence to the eyepiece to form the final image (Figure 3). In the darkfield system, used most frequently by the Laboratories, the rays from the light source are directed around the objective, strike an annular mirror or condenser, and illuminate the specimen. This is illustrated in Figure 4. Since a polished magnetic specimen is highly reflecting, all incident rays striking the surface are reflected away from the objective, and the field in the microscope appears black. However, the small colloidal magnetite particles, which have already aligned themselves along the domain boundaries, are illuminated by the light impinging on their irregular surfaces. Since no light emanates from the background, the reflecting particles appear white. This provides maximum visual or photographic contrast as illustrated in the domain micrograph (Figure 2).

Over the years, the colloidal magnetite method has been used extensively. In this work, through the efforts of W. O. Baker and F. Winslow of the Laboratories, further refinement in the preparation of colloidal magnetite made it possible to see the more delicate delineations of the domains, and to observe the changing domain patterns over a much longer period of time.

Of particular interest was the change in domain patterns caused by various physical influences such as inclusions or small surface defects. It was further observed that irregularities in specimen preparation, such as surface straining, would cause a type of domain pattern that was not representative of the underlying structure. In addition to presenting a static picture of domains under the influence of an applied magnetic field, these domains would move with a change in field intensity or direction. As a result, the domain patterns could be photographed and recorded in still or motion pictures. (The latter were taken by F. Tylee in collaboration with H. J. Williams and J. G. Walker.)

Although much was gained in the study of magnetic effects with colloidal methods, which are still used to great advantage, there are certain inherent

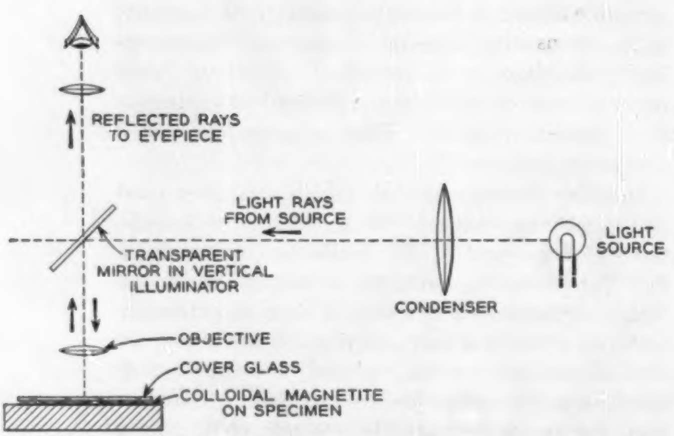


Fig. 3 — The "brightfield" system of illumination. Reflected light returns through the objective lens, transparent mirror and eyepiece to the observer.

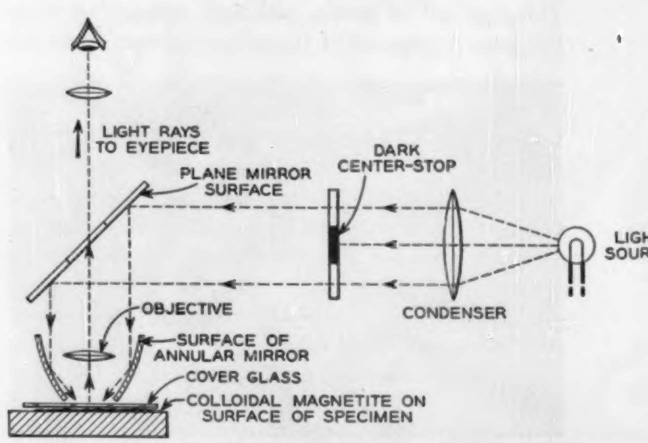


Fig. 4 — "Darkfield" system of illumination. Light is reflected from the specimen surface though the microscope lens system to the eye.

restrictions. Among these limitations are the time required for the particles to collect along the domain walls and the failure to delineate the fine structure that the microscope can resolve.

During the latter part of the nineteenth century, a useful effect was observed by the Scottish scientist, John Kerr. He found that, when a beam of polarized light is reflected perpendicularly from a surface that is magnetized normal to itself, the plane of polarization of the light is rotated. The direction of rotation depends upon the polarity of the reflecting surface. Thus, if the north pole

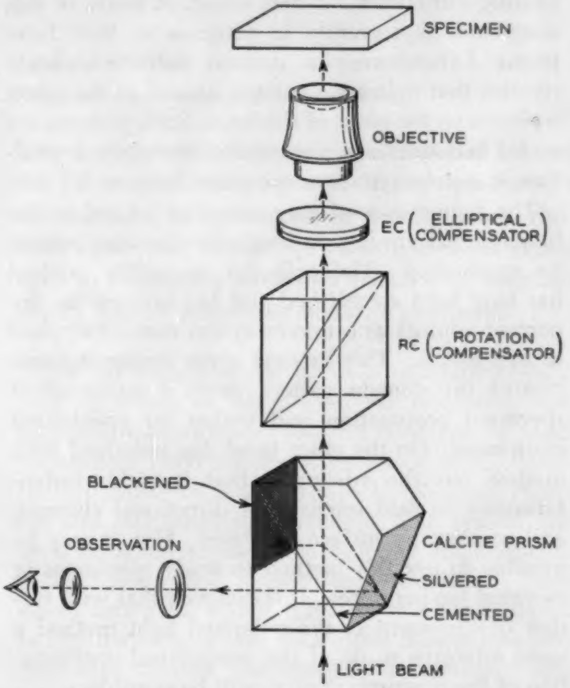


Fig. 5 — Adaptation of elliptical vibration compensator used in conjunction with metallograph for studies of domains in magnetic materials.

of a material rotates the plane in a clockwise direction, the south pole will rotate the plane in a counter-clockwise direction. It was thought that a study of the domains in a magnetic material might be possible using this effect. The phenomenon, known as the Kerr magneto-optic effect, was in 1950 applied to the microscopical study of magnetic domain structure in cobalt by H. J. Williams, E. A. Wood and the author.

In 1938, L. V. Foster of the Bausch and Lomb Optical Company described an illuminating system for a metallograph, using a cut and cemented calcite prism as a polarizing illuminator. Later, a polarized light compensator was developed to be

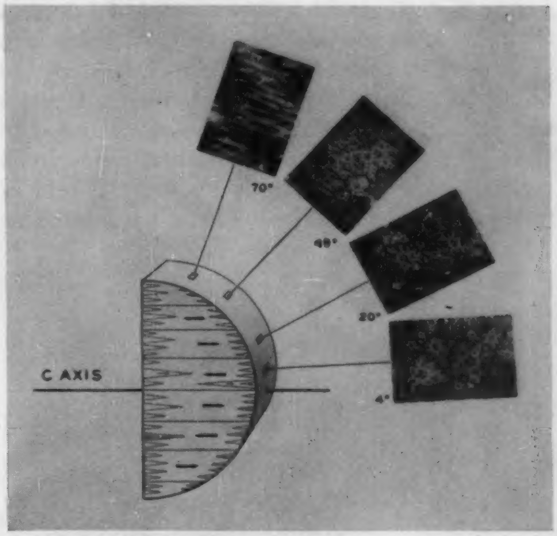


Fig. 6 — Domain structure in a cobalt crystal cut in the form of a half disc. At the 4-degree segment, the photomicrograph shows the ends of the fine domains, while at 70 degrees the domains are indicated as more of a side view.

used in conjunction with this metallograph for the study of opaque minerals. The combination of these two illuminating devices is shown in the diagram of Figure 5.

With this device, either the north or south poles in the surface of the specimen can be made to appear bright while the other set remains dark. This is done by adjusting the elliptical and rotation compensators, shown in Figure 5, to extinguish the light from one set of domains. When there is no compensation, both sets of poles or domains have the same intensity and they cannot be distinguished.

By means of this polarizing attachment for the metallograph, it was believed that the Kerr magneto-optic effect could be used to study the domain structures in magnetic materials. In the initial studies, using this effect, a single crystal of cobalt was selected. Subsequently, a cobalt crystal was made in the form of a half disc. With this shape crystal it was possible to observe domains between positions parallel to the c-axis, or easy direction of magnetization, to positions perpendicular to this axis. To minimize the possibility of a disturbed surface of cold worked material, the crystal was carefully electro-polished.

Cobalt has a hexagonal structure. In this element, the domains tend to lie with the direction of magnetization in either a positive or negative sense along the c-axis. The photomicrographs that are shown in

Figure 6, starting with a displacement of 4 degrees from the c-axis and advancing through positions to 20 degrees, 49 degrees and 70 degrees, illustrate the change of domain patterns from rosettes to elongated areas. On the surface perpendicular to the c-axis (Figure 6) the magnetization forms small regions having poles of opposed polarity. This gives rather complex domain patterns on the surface, as can be seen in the comparison photomicrograph, Figure 7. Photomicrograph Figure 7, left, shows a collection of magnetite particles (darkfield illumination) and Figure 7, right, is a direct view (polarized light) of the polished surface. The latter shows many fine details that cannot be seen in the colloidal magnetite picture.

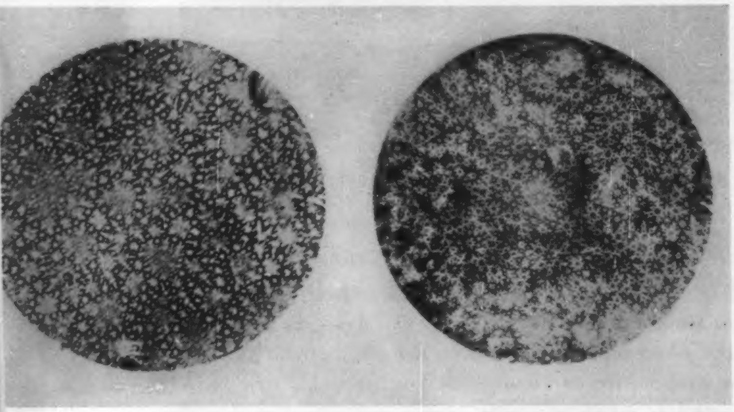


Fig. 7 — Comparison of techniques. (Left) Pattern obtained using colloidal magnetite. (Right) Polarized light pattern showing greater detail on same area of the cobalt crystal.

In the microscopy of the magnetic domains of cobalt it has been found that the contrast is very low and, at times, has caused considerable difficulty in visual study. Photomicrography with high contrast emulsion films and special development has further aided this study.

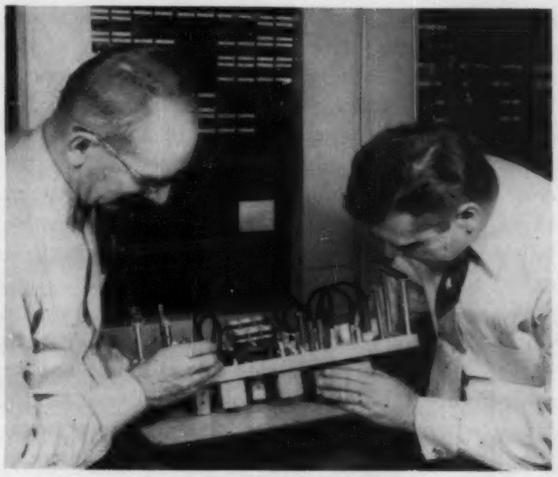
Recently, B. M. Roberts and C. P. Bean of the General Electric Research Laboratories have studied the ferromagnetic intermetallic compound manganese-bismuth. This also has a hexagonal crystal structure with the direction of easy magnetization along the c-axis. In this compound, a much greater contrast is achieved with the domain patterns appearing virtually black and white. A study of this compound is currently in progress at Bell Telephone Laboratories; a domain pattern showing rosettes that indicate a surface normal to the c-axis is shown on the cover of this issue. Such patterns are an aid in determining the orientations of the crystallites in a polycrystalline specimen.

The importance of microscopy as an aid in the fundamental studies of magnetic domains cannot be overlooked. The colloidal magnetite method has long been established and has become an important adjunct as a microscopical method applied to magnetism. This method gives strong delineation of the domain patterns with a minimum of specimen preparation and outlay for specialized equipment. On the other hand, the polarized light method has the advantage that it yields instantaneously to field intensity or directional changes, and employs no surface additives. Also, it may be possible to use this method to study specimens at elevated temperatures. It is believed that with further development of the polarized light method a more intensive study of the geometrical configuration of the magnetic domain will be possible.

THE AUTHOR

F. G. Foster came to the Laboratories in 1929. Supplementing his degree of B.S. in M.E. from Newark College of Engineering, he studied metallurgy at the Polytechnic Institute of Brooklyn and electron microscopy at Stevens Institute of Technology. He has taught metallography at the Newark College of Engineering and is currently a visiting lecturer at Stevens. Mr. Foster, a licensed professional engineer, is chairman of the American Society for Testing Materials Committee on Microscopy, Past Treasurer and Editor of Yearbook of the New York Chapter, American Society for Metals, Fellow and Past President of the New York Microscopical Society, Fellow of the Royal Photographic Society of Great Britain, Fellow of the Royal Microscopical Society, and member of Sigma Xi. The A.S.M. has granted him four awards for his microscopical work and the A.S.T.M., two. In 1956 he received the Ashby Plaque of the New York Microscopical Society.

Television Terminals for the L3 System



J. J. JANSEN
Transmission Systems Development II

The Laboratories has developed special television terminals for use with the L3 coaxial cable system. These terminals, which include a number of new circuits, are designed to accommodate the full bandwidth needed for both color and black-and-white television signals. They have made it possible to transmit a television signal over coaxial cable together with six hundred or more telephone message channels.

The L3 system operating over standard coaxial cable provides an 8-mc band for telephone and television transmission. The full band can be used to transmit 1,860 telephone channels, or the band can be shared by a 4.2 megacycle television channel and 600 telephone channels. The system has been designed to meet the exacting requirements of both color and monochrome television. Television terminals which translate the video signal to line frequencies and back again incorporate several new circuits that provide substantially improved television transmission.

To minimize intermodulation interference between telephone and television, it is preferable to use the upper portion of the transmission band for television, from almost 3.6 to 8.35 mc. The lower frequencies are used for telephone message circuits.

Television signals are modulated and demodulated in the transmitting and receiving terminals in steps as illustrated in Figure 1. After a low-pass filter limits the incoming video band from the television station to 4.2 mc, the transmitter modulates this band with a 4.139-mc carrier. Since a portion of the video band extends above the carrier, there is a slight overlap in the lower sideband. This is not troublesome, however, because that portion of the lower sideband is not transmitted. The resulting signal then passes through a filter that shapes the double sideband into a vestigial sideband signal.

Vestigial rather than single sideband transmission is used because the video signal includes energy at very low frequencies. It is impossible to design a filter which removes all of one sideband, leaves all of the other sideband, and maintains essentially constant delay from the upper sideband frequencies down to the carrier frequency. In vestigial sideband transmission, the sideband energy in the vicinity of the carrier is intentionally shaped by the filter so that at the carrier frequency, the sideband amplitude is exactly 50 per cent of its maximum value. The energy lost from the wanted upper sideband is then supplied by the "vestige" of lower sideband that remains.

To shift the carrier band back to the original video frequencies at the receiver, either of two methods could be used. Simple envelope detection by a rectifier or some other form of detector, as used in radio and television sets, is one method. Or, demodulation may be used to shift the entire sideband to any place in the spectrum – in this case, back to the original frequencies. The second method is used, and the demodulating frequency is exactly the same as the modulating frequency – 4.139 mc. This produces the wanted video band plus an upper sideband from about 8 to 12 mc. A low-pass filter removes the upper sideband, leaving the desired video frequencies.

A major consideration in the design of a carrier

Fig. 2 — W. F. Ranchle adjusts modulator balance.

system for wire or radio transmission is the depth or degree of modulation. This is a measure of the amount of modulating signal contained in the modulated carrier. Although a modulated carrier is actually a complex signal consisting of a carrier component plus all the sideband frequencies, it is often convenient to consider it as if it were a carrier alone with an amplitude that follows the modulating signal. A trace of this varying amplitude is called the envelope of the wave.

If the video signal were a low frequency sine wave – for example, the 60-cycle wave shown in Figure 3(a) – the modulated signal might appear as in Figure 3(b). The case of 100 per cent modulation, where the carrier is reduced to zero at negative peaks of the modulating signal, is shown in Figure 3(b). Ordinarily, modulation greater than 100 per cent is undesirable because simple envelope detectors cannot be used to recover the modulating signal. In fact, because of linearity limitations imposed by detectors, modulation is held considerably below 100 per cent to keep distortion to a minimum.

The 100 per cent modulated wave of Figure 3(b) contains considerable carrier frequency power. Its peak-to-peak amplitude is the average value of the modulated wave. The practical implications that arise from transmitting the signal shown in Figure 3(b) may be expressed in two ways: Line repeaters must have a load-handling capacity equal to at least $2V$ where the information is contained in V. Alternatively, in transmitting the waveform of Figure 3(b) the line is being loaded with a considerable amount of carrier. Where the percentage modulation is less than 100 per cent the carrier content is still higher. Since the load handling capacity of a system is more or less fixed, loading the facility with carrier power affects the signal-to-noise ratio adversely.

For a given envelope amplitude, the peak-to-peak amplitude of the signal may be changed by merely adding or subtracting unmodulated carrier. This process may be carried to the point illustrated in Figure 3(c), which is the minimum peak-to-peak amplitude that can be obtained. The over-all amplitude is now V, rather than 2V. Since the amplitude of the video information is unchanged, however, the waveform of Figure 3(c) makes possible a signal-to-noise improvement of 6 db compared to the waveform of Figure 3(b). A balanced modulator is employed in the transmitting terminal. In such a modulator circuit the output vanishes when the video signal is removed and the amount of carrier present in the output is directly proportional to the dc content of the video signal. The waveform of Figure 3(c) can therefore be adjusted by changing the dc input to the modulator.

A television picture, however, is considerably more complicated than a simple sine wave. Figure

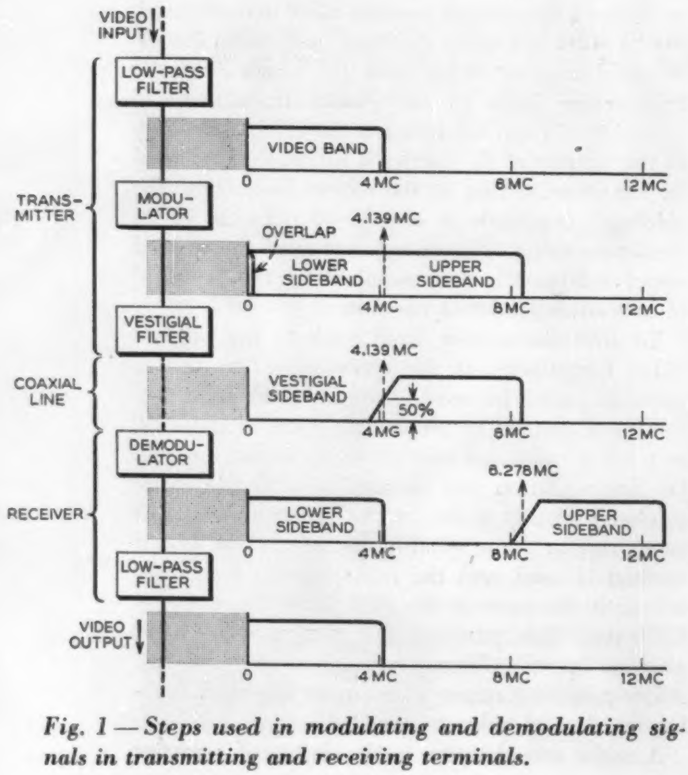


Fig. 1 — Steps used in modulating and demodulating signals in transmitting and receiving terminals.

4(a) represents the amplitude of one line of a television picture as it is traced across the screen where the picture consists of a white vertical bar against a black background. Black is represented at the reference level, the amplitude increasing as the picture becomes whiter. The synchronizing pulses, required by the television receiver for proper operation, are below the black reference level and

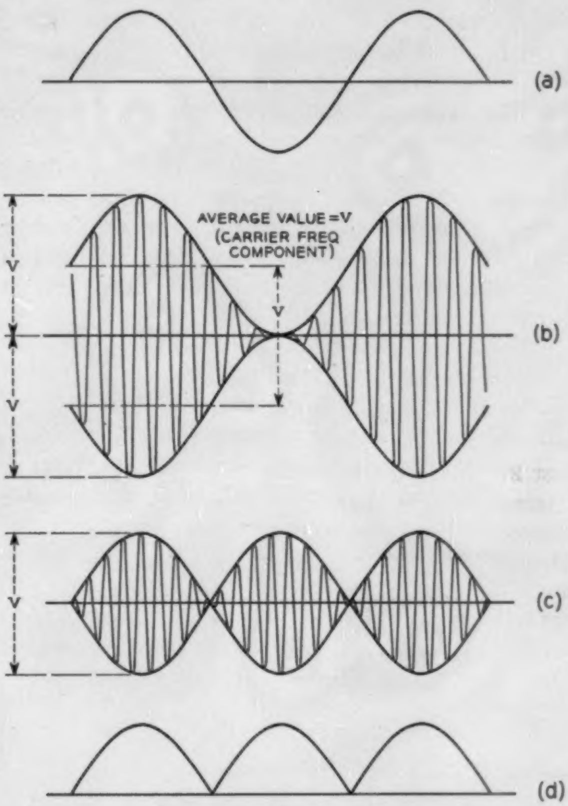


Fig. 3 — (a) 60-cycle sine wave; (b) carrier modulated by signal in (a); (c) minimum peak-to-peak amplitude obtained by adding or subtracting unmodulated carrier from (b); and (d) output obtained by applying (c) to an envelope detector.

are considered "blacker than black" because they have no effect on the picture brightness. The 100 per cent modulated case is shown in Figure 4(b). The maximum carrier amplitude is shown to occur during the synchronizing intervals, but this is not essential. Maximum carrier amplitude could also be made to occur at the peak white amplitude of the picture.

An important difference between the television signal and the sine wave is that the picture signal has an average value or dc component which depends upon the nature of the picture, whereas the average value of the sine wave is zero. This means that the degree of modulation of the television signal, and hence the peak-to-peak amplitude of the modulated signal depends upon the average picture content, as well as the instantaneous content. Consequently, the value of unmodulated carrier to be subtracted from the signal of Figure 4(b) to obtain the signal of Figure 4(c) also depends upon the nature of the picture. The dc input to the modulator is therefore regulated by an automatic control circuit to hold the peak-to-peak amplitude of the modulator output signal to V during synchronizing pulse intervals for all video signals. Thus, a full-amplitude video signal produces an output wave corresponding to Figure 4(c), while the output signal for a gray bar will appear as in Figure 4(b), but with a peak-to-peak amplitude of V. The output becomes V units of unmodulated carrier when the video signal is removed.

If the modulated wave of Figure 3(b) were applied to an envelope detector, the input signal of Figure 3(a) would be recovered. Applying the wave of Figure 3(c) to an envelope detector, however, produces an output corresponding to Figure 3(d). Hence an envelope detector is unsatis-

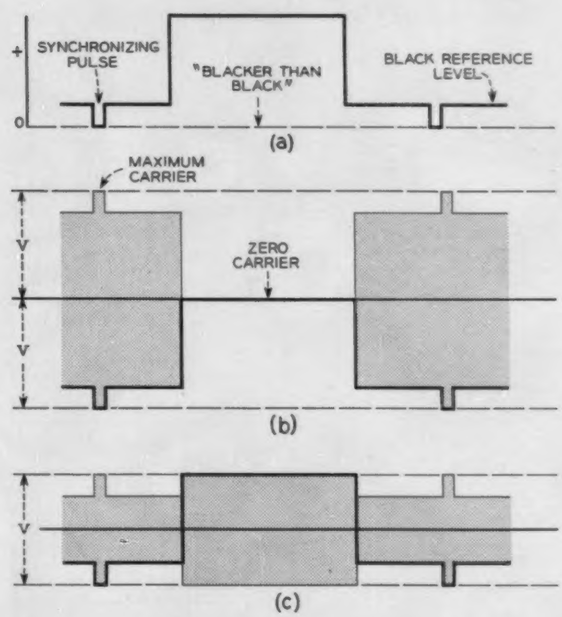


Fig. 4 — (a) Diagrammatic representation of one line of a television picture — white vertical bar against a black background; (b) 100 per cent modulation of the signal in (a); and (c) wave in (a) modulated for transmission.

factory in this case and a balanced modulator of the type employed in the transmitter terminal must be used to demodulate the signal back to the original video band. This requires a local carrier of the correct phase and frequency at the receiving terminal. The phase requirement must be very stringent to meet over-all system requirements – the demodulator carrier at 4,139 kc must track the incoming modulated carrier to within one degree. Hence, the improvement in the television signal-tonoise ratio in the L3 system, due to transmitting an overmodulated signal is obtained at the expense of considerable circuit complexity in the receiving television terminal.

The receiving carrier is reconstructed from information contained in the modulated signal. Since the carrier amplitude control circuit maintains the peak-amplitude of the modulated signal at V as shown in Figures 3(c) and 4(c), and since the television signal contains synchronizing pulses at regular intervals as shown in Figure 4(a), the energy content of the transmitted signal is known and suitable for frequency control purposes.

Although a description of the frequency control circuit is beyond the scope of this article, it may be observed that the receiving carrier can lock-up in phase with the incoming carrier, or it can lock-up 180 degrees out of phase. Either condition is equally likely. In one case the video output of the demodulator is positive, as given in Figure 4(a), and in the other case the output signal would be inverted. Such a situation might result when the incoming modulated signal is interrupted by a change in the television network – for example, at the beginning of a program. A circuit called a polarizer examines the signal at the receiver output and recognizes the polarity of the detected video. If the picture is negative, a relay inverts it before passing it on to the video output.

The terminals include many passive networks and, to a large extent, these networks determine the transmission performance. Particularly important is the vestigial filter in the transmitting terminal. It is quite complicated because it must accurately shape the transmitter band near the carrier so that the main and vestigial sidebands add in amplitude and phase to produce flat transmission over the entire band.

The L3 system uses six pilot frequencies for automatically regulating the transmission characteristics of the coaxial line,* and two of these pilots (7.266 and 8.320 mc) fall in the television band. Hence, narrow band filters tuned to these frequencies are required in both terminals. At the trans-

* Record, *October*, 1954, *page* 385.

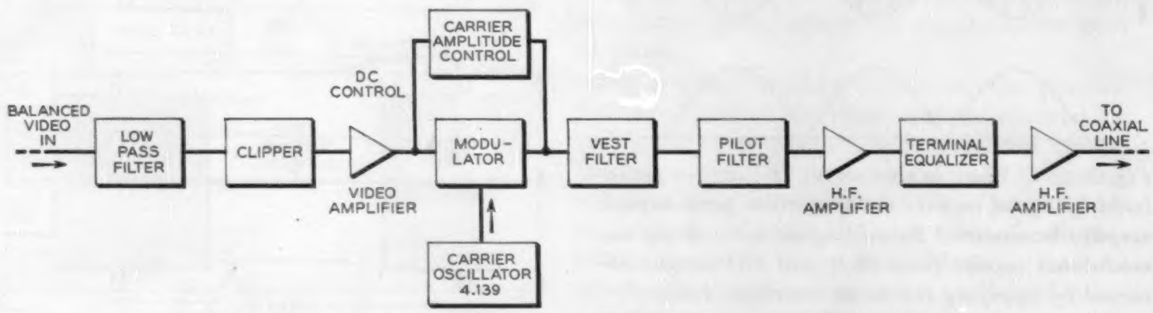


Fig. 5 — Simplified block diagram of L3 television transmitting terminal.

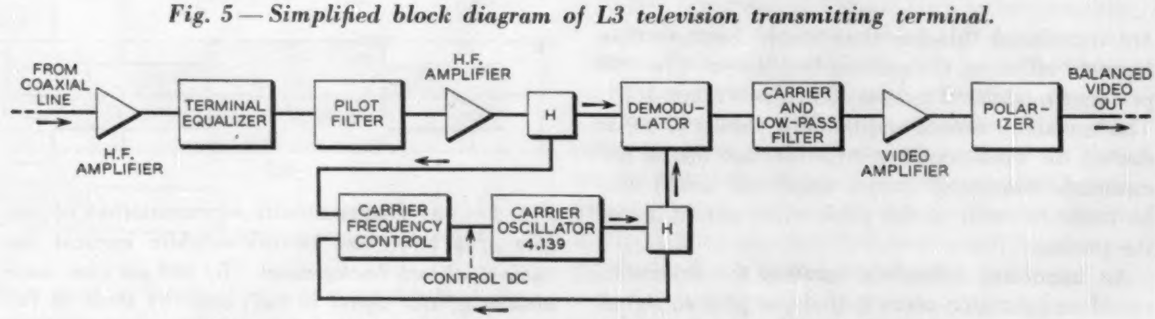


Fig. 6 — Simplified block diagram of L3 television receiving terminal.

mitting terminal, one such filter in the output prevents television picture energy at pilot frequencies from disturbing subsequent carrier-system regulators. In the receiving terminal, the filter suppresses the received pilots before they reach the demodulator, thus preventing objectionable bar pattern interference in the picture. A similar filter which is also located in the receiving terminal prevents the 4,139-kc carrier frequency from appearing in the video output.

Two other circuits in the transmitting terminal are of interest. One is the carrier-amplitude control that determines just how much unmodulated carrier must be added to the modulated carrier to maintain the desired amplitude of the modulated signal. The second is a clipper circuit which protects the telephone message channels against video overloading. This circuit is inoperative at normal video levels and limits the amplitude of excessively high video signals to prevent the system from being overloaded.

Simplified block diagrams of the transmitting and receiving terminals are shown on Figures 5 and 6, respectively. Both terminals operate from 60-cycle ac power – either commercially supplied or taken from the output of the L3 motor alternator equipment at main repeater stations.* Nonregulated selenium rectifiers are operated from magnetically regulated ac supplies.

This terminal equipment is expected to find widespread use in L3 systems as they are gradually applied to existing coaxial cables throughout the country. The first commercial use of these terminals was in November, 1954, on a circuit between West Palm Beach and Miami, Florida. Other systems including those between San Antonio and Corpus Christi, Texas, between Indianapolis and Louisville, and between Los Angeles and Oakland are now in use.

* Record, *June*, 1955, *page* 220.

THE AUTHOR

J. J. Jansen received the B.S. and M.S. degrees in Electrical Engineering from Massachusetts Institute of Technology in 1939 and joined the Laboratories in the same year. Except for the duration of World War II, when he was engaged in various aircraft radar projects, his work has been largely concerned with television transmission. In addition to working on the television terminals for the L3 system and the amplifiers for the A2A system, he has also engaged in exploratory work leading to the television terminals for L1, short-haul TV transmission systems, and recently, terminals for the TH system. At the present time he is concerned with L3 system problems. Mr. Jansen is a member of Sigma Xi and Eta Kappa Nu.

Bell System TV Shows Win Two National Awards

"Our Mr. Sun," the first program of the Bell System Science Series, and "The Man With the Beard," a Telephone Time show, have been awarded high honors for television programs presented in 1956.

"Our Mr. Sun" was voted "The Television Program of the Year" as well as the "Outstanding Educational Program of the Year" by the National Association for Better Radio and Television. In addition, film editor Frank Keller of Frank Capra Productions, Inc., won an "Emmy" award from the National Academy of Television Arts and Sciences for the "best editing of a film for television" for his work on "Our Mr. Sun."

"The Man With the Beard" received a Brotherhood Award from the National Conference of Christians and Jews for the story's outstanding work in promoting the ideals of justice, tolerance and brotherhood. Telephone Time, seen for the past year on the CBS network on Sundays, has recently shifted to Thursday evening on the ABC network.

For the "Our Mr. Sun" program and others in the Science Series, meticulous care has been taken in the preparation to make each production not only entertaining and interesting, but scientifically accurate. To insure that the telecasts are authoritative, an advisory board of experts in various fields has been engaged to work closely with the Bell system. Dr. Ralph Bown, formerly Vice President-Research of the Laboratories, now retired, is chairman of this board and the consultant on Engineering. Dr. Bown has been closely associated with the development of the series from its inception.

Conversion of automatic ticketing step-by-step offices to AMA operation is a job of major proportions, involving cooperation of the Laboratories, the Operating Company concerned, and the Western Electric Company. Some of the equipment has to be modified on the spot, because of its size and complexity. Other equipment, small enough to be moved, can be modified in centralized Western Electric Repair Shops. Coordination of the various aspects of the conversion is an absolute "must" if telephone service is not to be disrupted.

Converting Automatic Ticketing to Automatic Message Accounting

W. R. BALDINGER *Switching Systems Development*

THE CONVERSION OF STEP-BY-STEP offices from automatic ticketing (AT) to automatic message accounting (AMA) operation was undertaken to gain the advantages of the automatic billing methods employed in crossbar AMA systems. With automatic ticketing operation, charging information on short-haul toll calls equivalent to that formerly prepared by an operator is printed automatically, but the tickets require manual processing by the accounting department. In AMA operation, the information is perforated on a paper tape that can be mechanically processed at the accounting center.

In the Los Angeles area there are seventeen automatic ticketing installations and in the San Francisco area there are five. About 29 million billable tickets were originated in 1950, and it has been estimated that nearly 280 million tickets will be produced in 1958. The addition of the no answer and partial dialing tickets that require equipment operation but no billing, brings the expected total tickets to about 400 million in 1958.

Conversion of the twenty-two existing installations involves the modification of some 800 senders, 5,500 trunks, and 90 identifiers together with associated recorders, perforators, transverters, call identity indexers, connectors and test equipment, Figure 1. A conversion of this magnitude requires methods that will permit the project to be completed within a reasonable interval of time with due consideration for the many other factors involved, such as production, distribution and installation. It must, of course, also be possible to maintain satisfactory call-carrying capacity with as little effect as possible on service.

Plans for conversion were developed on the basis of sender groups (5 maximum) into which the offices are divided. Each sender group consists of twenty or fewer senders together with 198 or fewer trunks. A maximum of ten identifiers with associated test and connector equipment are common to all sender groups. When a sender is changed from controlling a trunk ticketer to controlling an AMA recorder, it is altered to such an extent that it is necessary to divide the sender group into two subgroups, each with its own type of sender and trunk circuits. A sender group thus split does not have the call-carrying capacity of the original.

As a result of this and because some senders will be out of service during the conversion, it may be necessary to add new senders and redistribute traffic to maintain satisfactory call-carrying capacity. Where the limitation of twenty senders per group may prohibit adding more senders, it will be necessary to add an additional group. If several senders in one office are converted simultaneously, a larger number of new senders will be required

than when the senders are modified successively. Floor space requirements for new senders may also be a major factor in a conversion.

A redistribution or shift in traffic or the utilization of light load periods must not be overlooked in minimizing the number of new senders needed. Traffic may be transferred, in many cases, by temporarily cabling a sender into a sender group from another group having spare capacity. It is also possible, since the efficiency of a new or converted sender is greater than that of an older sender, that after a sender group is converted, its increased capacity will permit moving traffic into it from the next group to be converted.

The conversion procedures are based on (1) the establishment of a centrally located conversion center in the Los Angeles Distributing House of the Western Electric Company where the many small trunk units will be sent for modification on a production-line basis, and (2) "on the job" modification of the large sender units by local installation forces. The headpiece and Figures 2 and 3 show some of the work involved at the conversion centers. To be efficient, the trunk conversion centers must be in continuous operation during the conversion, with a fairly uniform output in step with the sender modification rate. To bring about a practical conversion, it is necessary to divide the procedures into three phases – preliminary, transitional and final. The conversion sequence chart that is shown in Figure 2 indicates the equipment status during the three phases.

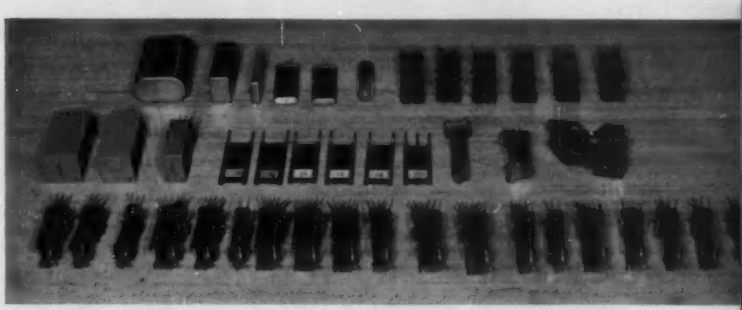


Fig. 2 — Apparatus components shown are removed from automatic ticketing trunk unit and re-used in AMA trunk.

The preliminary phase is that period when new AMA equipment is installed and certain existing equipment that must operate with both old and new equipment during the conversion interval is modified. The new AMA equipment units, Figure 4,

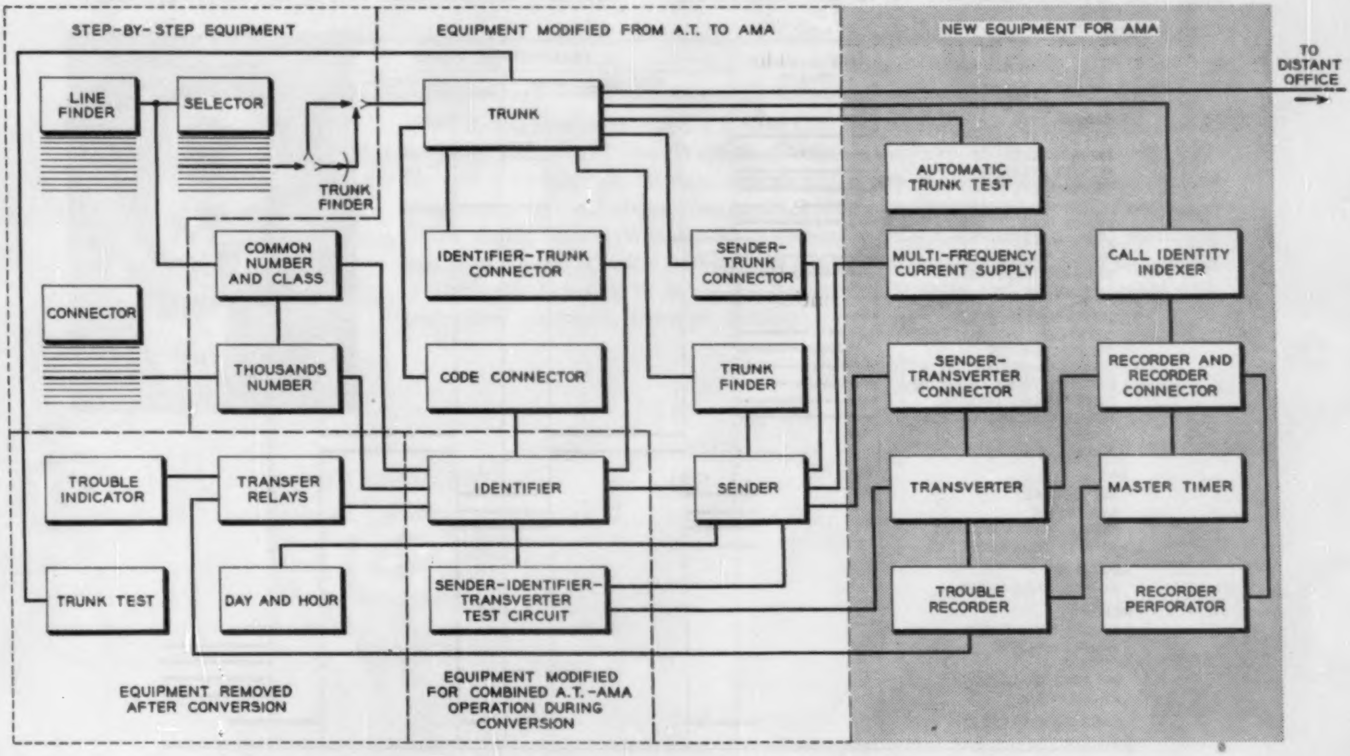


Fig. 1 — Block diagram of equipment units before, during and after the conversion.

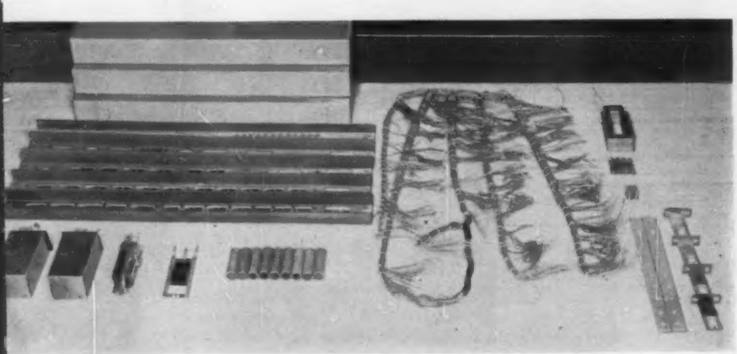


Fig. 3 — Additional apparatus required in converting automatic ticketing trunk to AMA trunk at conversion centers.

are added, tested and cabled, but only the portion of the cabling that will not adversely affect working circuits is connected.

Existing office equipment that is common to all sender groups includes the identifiers and the sender-identifier test frame. The test frame must be modified first so that it can test the identifiers after they have been arranged for dual operation. Before the identifiers can be allowed to operate with AMA equipment, an auxiliary relay circuit must be provided to connect test leads either to the existing lamp-type trouble indicator or to the new AMA trouble recorder, depending on the type of call being handled. After these modifications and additions have been made, the new sender and trunk equipment required for the first sender group to maintain an acceptable call-carrying capacity is installed. Along with these changes, the associated connector equipment must be added.

Work involved in the preliminary phase can, for the most part, be carried on during regular working hours. The regular office maintenance identifier is substituted for an identifier under modification, so the equipment conversion is confined as nearly as possible to a week-end or other extended periods of light load. Conversion of the sender-identifier test frame should keep it out of service for short periods only, since it is required for tests a large part of the time. Although most of the conversion effort for the senders takes place during the second or transitional phase, some initial work can be accomplished during the preliminary phase. One example of this is the use of a supplementary-frame local cable so that new cables may be installed and those leads connected that will not interfere with existing service.

The transitional phase is that period when senders and trunks are being modified. This phase is the most critical, since loss of call-carrying capacity

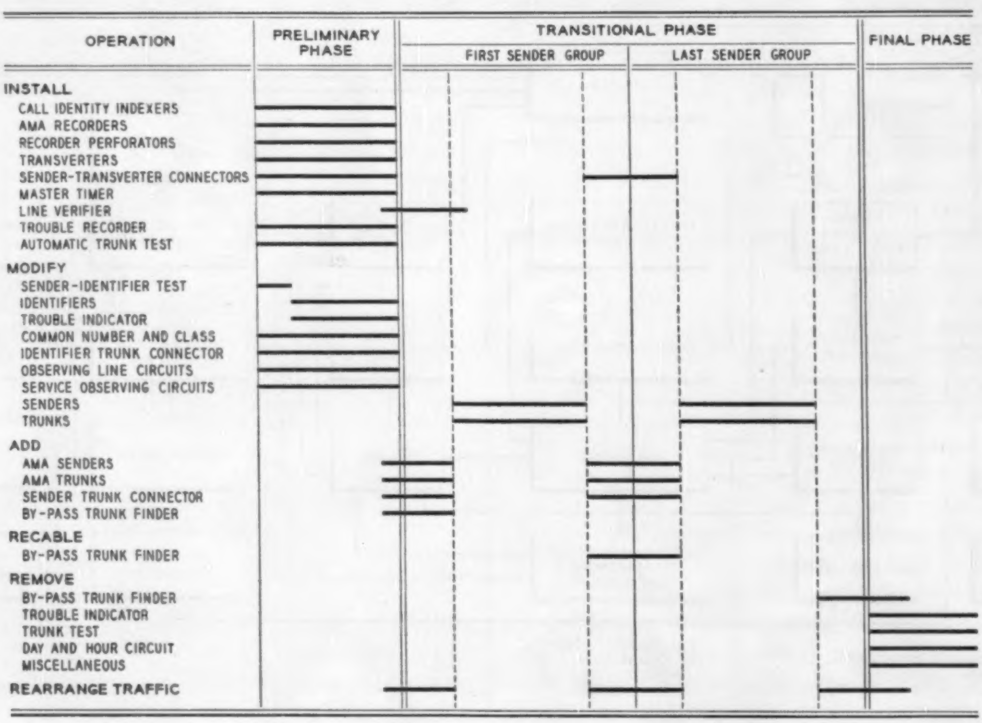


Fig. 4 — Sequence chart of the various steps involved in each phase of the conversion.

is encountered during this time. After all trunks and senders in a group are converted for AMA service, the transitional phase for that particular sender group is complete. The transitional phase for two successive sender groups is separated by a short period during which the bypass trunk finder is recabled into the next sender group, AMA trunks and senders as necessary are installed, and traffic is redistributed as may be necessary.

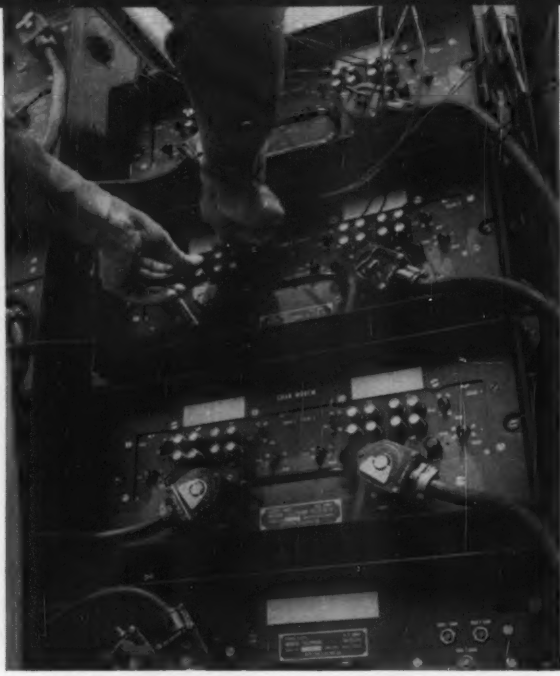
The final phase is entered after all senders and trunks have been converted. During this period all equipment not required for AMA operation will be removed. It will also be necessary to remove temporary modifications in the sender-identifier-transverter test frame, trouble recorder and identifiers, since only AMA calls need to be processed. A final redistribution of traffic may also be warranted. With the exception of this last item, this phase can be carried out during normal work hours.

Each automatic-ticketing trunk frame contains five trunk units and five 1-A message ticketers. After conversion and the removal of the message ticketers, ten AMA trunk units can be mounted in each frame. Where floor space must be conserved, trunk circuits may be relocated after conversion to fill out the frames. The top five units will re-use the original trunk cabling while cabling for the five lower units will be cut back from the frames where the older trunk units were originally mounted, or new cabling will be run in. The basic pattern for this "doubling-up" of trunk units involves making available consecutive trunk frame space and at the same time using as little new cable as possible. The floor space recaptured by mounting ten AMA trunk units per frame instead of five will, however, not be readily available since all new equipment must be installed prior to the conversion.

This project demonstrates typical Bell System teamwork. Coordination of Laboratories development, A.T.&T. and Operating Company planning and Western Electric manufacturing, installation and distributing-house activities permit a conversion of this magnitude to be accomplished with the timing and precision essential for uninterrupted service to telephone customers. Now in full swing, the entire project should be completed next year.

THE AUTHOR

W. R. Baldinger received a B.S. in C.E. degree from the University of Illinois in 1933 and joined the Western Electric Company at Hawthorne in 1936. He was a member of the line engineering group there for eleven years before transferring to the Laboratories in 1949. He served three years with the Signal Corps during World War II. Since coming to the Laboratories, Mr. Baldinger has been concerned with step-by-step equipment development in the conversion of automatic ticketing to automatic message accounting and more recently with centralized automatic message accounting at step-by-step intertoll offices.



A Basic Modulation Unit for Military Carrier Systems

A. E. PETERSON
Military Communication Systems Engineering

Two new carrier telephone systems for the military services make use of a basic group of four channels. For these channels a modulator and demodulator section termed a "modem" has been designed as a lightweight, easily maintained unit. Like all other parts of the four- and twelve-channel systems, the modem will withstand rough handling and will operate over an extremely wide range of climatic conditions.

Because modern military tactics place great emphasis on good communications, there has been an increased need for the carrier type of telephony – that is, for placing more than one conversation on a pair of wires or on a single radio circuit. Carrier telephone systems have long been used to provide communications for both military and commercial use. Recent developments at Bell Laboratories have included two new carrier telephone systems for the armed forces – one, a four-channel system and the other a twelve-channel system.*

An essential part of these two systems is the basic modulator and demodulator unit, known as the TA-219/U modem. This unit translates the voice signals of each of the several channels to their assigned place in the frequency spectrum and consists of equipment and circuitry for four channels. The twelve-channel system uses three such units and applies further modulation and demodulation to the groups of channels, as is commonly done in Bell System commercial systems. The four-channel system uses one such unit, and the output frequencies are transmitted directly over the line.

Figure 1 shows the frequency allocations of these four channels. As is well known in carrier technology, if we amplitude modulate a carrier with a band of voice frequencies, the modulated output ordinarily consists of three main components: (1) the carrier frequency, (2) a band of energy containing voice intelligence at frequencies determined by adding the values of the voice frequencies to the value of the carrier frequency (C + V), and (3) another band of frequencies determined by substracting the voice band from the carrier (C – V). These latter two components are referred to as the upper and lower sidebands of the carrier. Since either sideband contains all the essential voice intelligence, it is common practice in many systems to suppress the carrier and to eliminate one of the sidebands. This is what is done in the modem unit. Elimination of one sideband provides a 2-to-1 reduc-

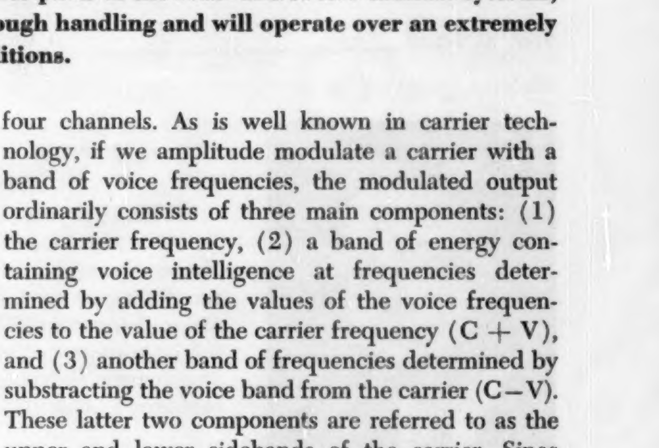


Fig. 1 — Frequency allocation in the modem unit, showing use of lower sidebands; carrier frequencies are suppressed.

* RECORD, *August*, 1955, *page* 290; *October*, 1955, *page* 382; and *January*, 1956, *page* 21.

tion in the frequency space required. As shown in Figure 1, only the lower sideband is used; the upper sideband is filtered out and the carrier is suppressed for each channel.

In addition to improved electrical characteristics, the modem unit incorporates several new equipment design features. It occupies a volume only about two-fifths that of previous equipment used for this purpose. To achieve this reduction in size, it was necessary to develop special miniature transformers, filters, and other components. At the same time, these components were made rugged to withstand the severe mechanical shocks to which they will be subjected in normal military use. The equipment design work of R. R. Andres of the Laboratories contributed substantially to the development of this unit.

The basic parts of the transmitting portion of a channel are shown in Figure 3. As seen in this illustration, voice and carrier frequencies are supplied to a modulator, and the output consists of the lower sideband. Voice frequencies reach the modulator through a low-pass filter, which rejects all frequencies above about 4,000 cycles-per-second. The carrier frequency reaches the modulator through the temperature-compensating attenuator seen in Figure 3. This circuit is designed to reduce variation of the carrier level with changes in temperature. Carrier systems usually require an amplitude limiter to prevent amplifier overload, but in this system the modulator inherently performs a limiting function which is primarily controlled by the carrier level. The temperature-compensating attenuator controls this level over the wide temperature variations encountered in military use. Compensation is achieved by the use of thermistors ("thermally sensitive resistors") whose change in resistance with temperature provides the desired control.

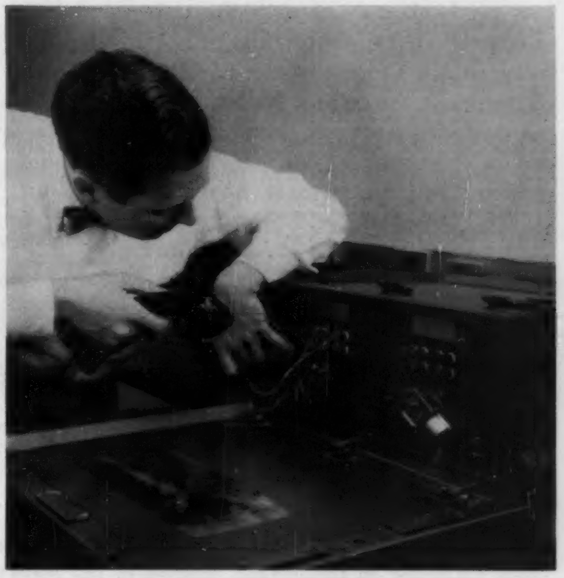


Fig. 2 — The author inspecting a four-terminal TA-219 U modem unit in the laboratory.

Four copper-oxide varistors really form the heart of the modulator section. They are incorporated into what is termed a "double balanced" structure, the unique property of which is that when the carrier and voice frequencies are applied, the output con-

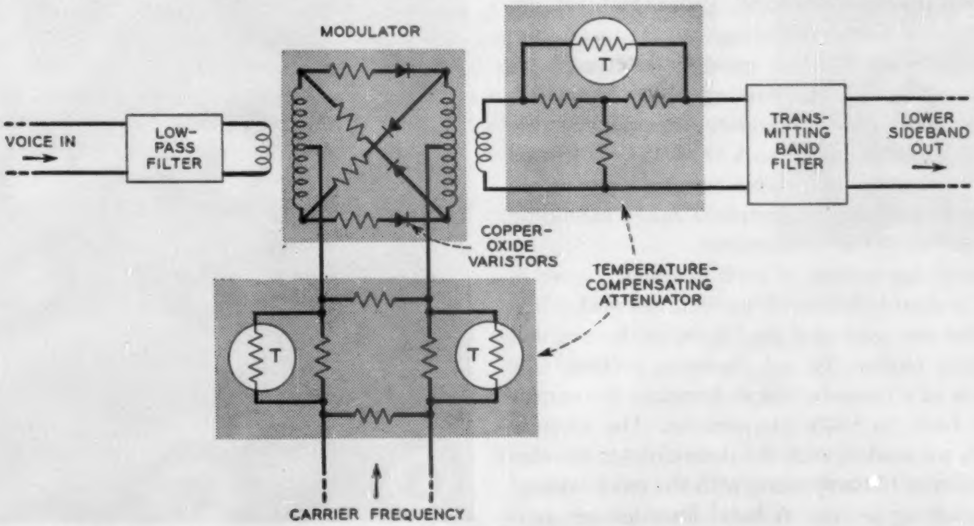


Fig. 3 — Channel transmitting section with "double-balanced" modulator and thermistor-controlled temperature-compensators in the carrier and output circuits.

sists predominantly of only the upper and lower sidebands. That is, the original voice frequencies are balanced out and the carrier is suppressed. In this arrangement, the resistor in each leg of the structure is a deviation from the usual circuit of this type; it aids in compensating for manufacturing variations and temperature changes in the individual varistors, thereby producing better carrier balance or cancellation to improve the transmitted signal.

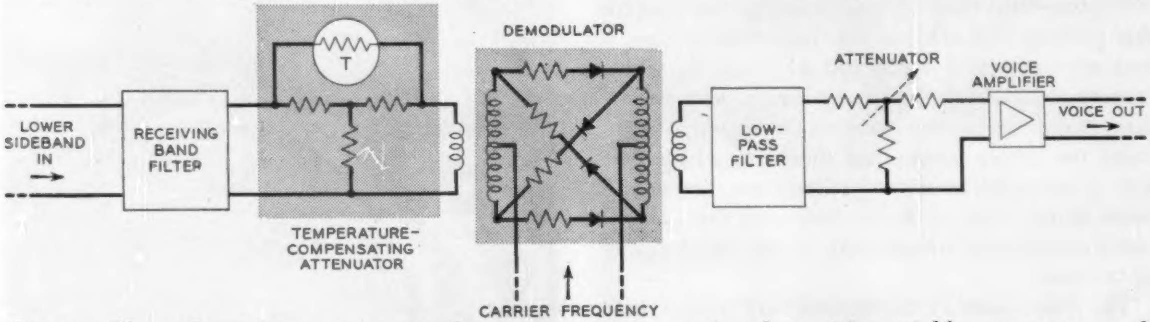


Fig. 4 — Channel receiving section, similar to transmitting section but with variable attenuator and voice amplifier in the output portion of the circuit. Attenuator adjusts signal level.

Following the modulator is another temperature-compensating attenuator incorporating a thermistor. This network provides a resistive termination for the modulator and also compensates for variations in transmission loss with temperature. The last circuit indicated in Figure 3 is the transmitting band filter, which readily passes the lower sideband frequencies but rejects the upper sideband and any other unwanted modulation products that may be present. By the use of this combination of networks in the channel transmission section, the desired voice-modulated, carrier-suppressed, lower-sideband signal is produced for transmission.

It will be noticed that a great deal of emphasis has been placed on maintaining transmission stability through the use of temperature-compensating attenuators. The need for such networks is dictated by the requirement for stable transmission over a very broad operating temperature range extending from —40° to +130° Fahrenheit.

The receiving section of each channel, Figure 4, contains a double-balanced varistor network identical to the one used as a modulator in the channel transmitting section. In the receiving section, this unit serves as a demodulator to translate the carrier channels back to voice frequencies. The circuits intimately associated with the demodulator are also quite similar to those working with the modulator of the transmitting section. A band filter assures passage of the proper frequencies through a temperature-compensating attenuator to the demodulator. A low-pass filter passes the voice frequencies while suppressing the unwanted higher frequency components of the received signal.

The channel receiving section, however, also contains a voice-frequency amplifier. The amplifier has an attenuator in the form of a dual potentiometer, which permits adjusting the voice signal level at the amplifier input. This enables the amplifier to deliver the proper level to the associated voice equipment. The use of a dual potentiometer in the amplifier input circuit permits signal-level adjustment while maintaining a constant impedance amplifier input termination. This potentiometer termination, as seen through the low pass filter, also pre-

Fig. 5 — G. E. Harper testing modem section; other sections are in pull-out drawers in transit cases.

sents a resistive termination for the demodulator. The amplifier has approximately 40 db of gain with 7 db of feedback.

The circuitry of each individual channel also includes a four-wire terminating set, whose circuit is shown as Figure 6. Since the carrier system is a four-wire circuit (one pair of wires for transmitting and a second pair for receiving), and since the usual telephone connection is a two-wire circuit, some provision had to be made for joining one to the other when necessary. This is done in the terminating set with what is essentially a hybrid coil, which has this property of converting from four-wire to two-wire operation. An arrangement is available for switching the hybrid in or out of the channel transmission path. When the hybrid coil is used, the input and output transmission levels at the hybrid, as referred to an associated switchboard, are 0 db and –3 db respectively. When operating four-wire, the transmitting and receiving path bypass the hybrid coil. A channel input transmission level of –4 db, and output of +1 db is used during four-wire operation of the equipment.

The modem is a rugged, compact, lightweight unit. The use of individual plug-in channel units in this equipment makes for quick access to its electrical circuits and permits rapid maintenance or replacement of defective units. Important assets to the channel performance are a modulator and demodulator having the desired transmission characteristics, including a controlled limiting curve, stabilized with temperature. The modulator and demodulator also afford excellent carrier balances without adjustment and achieve uniformity in manufacture. This basic modulation step for military carrier systems provides performance comparable to that of the commercial equivalents while operating under extremely adverse climatic conditions.

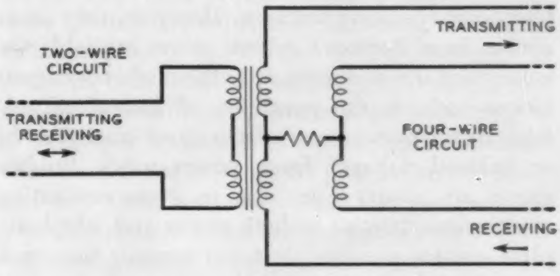


Fig. 6 — Four-wire terminating circuit for each individual channel: hybrid coil arrangement is used to convert from four-wire to two-wire operation.

THE AUTHOR

A. E. PETERSON, JR. graduated in 1949 from Madison Institute where his studies were mainly in the field of radio engineering. At that time, he was engaged in electronics work as a civilian for the United States Coast Guard, where he was concerned with experimental design and development of crystal-controlled frequency devices and other electronic control circuits, and with transmitters for radio beacon applications. During World War II he served with the Navy in the Pacific Theater. Mr. Peterson joined Bell Telephone Laboratories in 1950 and was initially engaged in work on carrier supplies and amplifiers, and later undertook work on the modems for the new military carrier equipment. At present, he is engaged in a communications study for the Signal Corps.

New Gloves for Linemen

Unlike linemen who work for electric power utilities, Bell System linemen do not ordinarily handle wires energized by voltages above normal telephone operating voltages. However, they must always have linemen's rubber gloves available for emergency use and must wear them whenever conditions indicate the possibility of hazardous voltages on telephone circuits from direct contact with, or induced voltages from, power wires. Rubber gloves are always worn also in storm restoration work where damage to both power and telephone plant creates possible electrical hazards that cannot ordinarily be determined.

The wearing of gloves of any kind restricts to some degree the freedom of movement of the hands and decreases the wearer's sense of touch. To minimize these disadvantages, the Bell System has recently adopted a lightweight rubber glove combination to replace a heavier and more bulky type which tended to reduce considerably the linemen's working efficiency. Field trials have indicated that, with the new glove combination, linemen work with about the same efficiency as when wearing the leather work gloves customarily used in line construction work involving no electrical hazards.

The new combination consists of three glove components: the liner glove worn inside the rubber glove, the rubber glove, and the leather glove worn outside of the rubber glove. Each glove unit has been designed to have as little bulk and as much flexibility as possible.

The rubber glove, which is about 1/32" in thickness, is loose fitting, since a tight glove would offer too much resistance to the easy flexing of the hands and fingers. It is of the gauntlet type (having cufflike extensions) with curved fingers and is 14" long. Specifications require that each rubber glove have a minimum electrical breakdown of 17,000 volts rms and, to insure suitability for continued service, all rubber gloves are proof-tested once every six months at 10,000 volts rms for a period of three minutes.

The form-fitting liner glove is made from a very lightweight, stretchable, circular-knit cotton material. Also of the gauntlet type, this glove provides some warmth in cold weather and also absorbs perspiration. The gauntlets serve two purposes: they prevent the wrist section of the gloves from working down and matting in the palm of the wearer, and they assist the lineman in pulling on the three-glove combination as a unit after gloves are removed, such as during a short break in working operations.

The leather protector glove is made from soft, flexible deerskin, is equipped with rubberized fabric gauntlets, and has an adjustable draw strap at the back. This glove is one inch shorter than the rubber glove to prevent a direct electrical conducting path from the leather, especially when wet, to the arms of workmen. To eliminate bulkiness and to increase wearer efficiency, most of the seams of the gloves are sewed "moccasin-style" on the outside along the back of the fingers, instead of between the fingers.

The components of the glove combination form a working unit whose job is to protect the lineman

Left, fabric liner glove worn beneath rubber glove; center, lineman's rubber glove; and right, leather protector glove worn over rubber glove.

from possible injury. The rubber gloves give the desired electrical protection, the liner gloves provide greater comfort for the user, and the leather gloves furnish mechanical protection for the rubber gloves. Each part is an essential member of the lineman's glove combination.

W. H. S. Youry
Outside Plant Development

C. F. Craig Speaks on "Tomorrow's Managers"

In a talk entitled "Tomorrow's Managers," given April 9 at Massachusetts Institute of Technology, Cleo F. Craig, chairman of the board of A.T.&T., said "Our job as managers today is to do everything we can to help the oncoming talent get its greatest opportunities for growth . . . to create the climate in which they will flourish." The occasion of Mr. Craig's talk was the Fifth Anniversary Convocation of the School of Industrial Management of M.I.T.

Today's and tomorrow's managers must extend their knowledge and broaden their thinking, Mr. Craig said. Their exposure to different points of view is essential. And courses and case discussions are worth a great deal when they light up men's minds and cause them to burn brightly. But, he pointed out, all the management training and development programs from here to Hong Kong will never of themselves make a man a top manager.

Establishing a Climate of Growth

"What then can we do? What process, what conditions, what climate will cause more and better managers to emerge in the future?" Mr. Craig asked. He answered this question by saying that, "People in business grow mainly from the jobs they are assigned to do and the way they do them. Delegation provides the route for men to grow to higher responsibilities.

"If we try to get people to become something we'd like them to be, then, whether we mean to or not, we're limiting their possibilities right from the start. Only when we work to remove all limitations to growth can we expect that the exceptional qualities of able men will emerge to the full, and in ways that no one, including themselves, could have foreseen.

"For example," Mr. Craig continued, "I think we should get young people into the situation of having to make real decisions early in their careers. And I mean hard decisions. After all, the necessity to choose between different courses of action is the essence of business discipline.

"We can expect quite a few mistakes but they have two great advantages," Mr. Craig said. "First, the people who make the mistakes will learn more from them than from all their successes. Second, making mistakes early is a good vaccination against making more expensive ones later.

"Another essential I'm sure is to watch incentives carefully . . . Still another way to give people room is to give them experience in different kinds of jobs . . . I'm talking about a real test every time on a real job every time . . ."

"These then are a few of the things we might do to encourage men in their desire to grow – to become all they are capable of becoming. But again let me emphasize that the first need is always for us to accept, believe and act on the basic principle that a man's growth must be his, and not something to be fashioned according to another man's ideas of what he ought to be. Once we proceed on this basis, and only then, we can provide the indispensable favorable climate which really inspires men to grow and keep growing."

New Management Concepts

Mr. Craig pointed out that management's progress in the last generation or so has been materially aided by some important changes in the conception and practice of the art of management. He mentioned three. First was the widening and deepening of the sense of trusteeship brought about by the ever-broadening base of ownership. A second aspect of progress, Mr. Craig said, is that managers have been increasingly alert to foster and encourage technical advances. Although the costs were high and the risks great, managements have been willing to accept them. Finally, he added, top managers have learned to decentralize and distribute authority to a greater degree than ever before.

In defining a manager's duty to the owners of the business, Mr. Craig said he must keep the business in a healthy state – ever expanding, as the nation needs expansion – and ever progressing. The financing of this progress should come out of earnings, he added, so that expansion will not depend mainly on fresh supplies of outside capital. He was convinced, he said, "that for any business, regulated or non-regulated, ability to expand out of earnings is the strongest incentive to progress . . ."

In closing, Mr. Craig said that "all our history tells us that the right way to live and work and achieve is to give men real freedom to become all they can be. . . . The approach I've been trying to express seems to me distinctly American. We've put fewer obstacles in the way of talent – obstacles of birth, education, of money, of class – than other nations have. This country has grown great and our industry leads the world because here more than elsewhere we're acting on the conviction that everybody ought to have full opportunity to show what he can do."

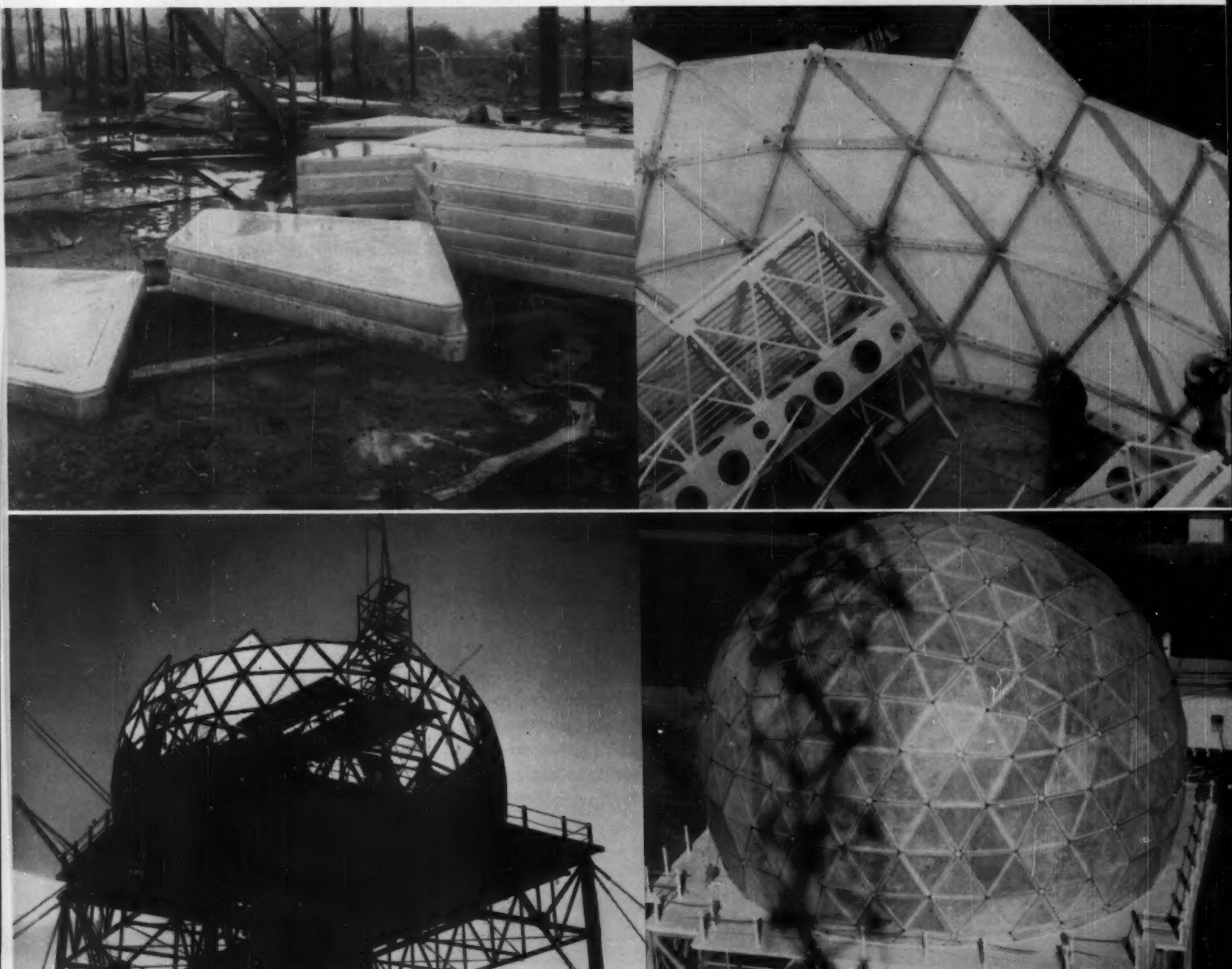
First DEW Line Sites Turned over to Air Force

The Western Electric Company, prime contractor for the Distant Early Warning (DEW) Line project, has announced that the first three sites have been completed and turned over to the U. S. Air Force. The event begins the final chapter in the construction of the 3,000-mile chain of interconnected radar stations across the Arctic from Alaska to Baffin Island. H. G. Ross, W. E. DEW Line Project Manager, described the project as a "full-scale attack on the Arctic unparalleled in military history," and added that the men working on the project, "broke all the rules of the book and made a frontier which, for many years to come, will play a major role in keeping alive a way of life which makes the DEW Line worth every effort put into it."

As part of the overall project, Bell Telephone Laboratories was responsible for the design of the DEW Line radar and communications network to detect enemy aircraft and flash warnings to defense commands seconds after the aircraft come into radar range. For testing the radar antenna and associated equipment, a complete "radome" was built at the Whippany, N. J., Laboratories location.

On the occasion of the official turnover, Western Electric released background material on the project. Included were the facts that over 200 miles of roads were built at DEW stations and that since

Steps in the construction of geodesic "radome," which has become a symbol of the Arctic DEW Line project.



inception, over 9,600,000 cubic yards of gravel have been required for roads, airstrips and concrete work. Since the beginning of the project, 557,000 drums of petroleum, oil and lubricants have been shipped to the Line. The 1956 sealift of DEW Line supplies consisted of 54 ships from Seattle and 24 from Norfolk. Airlift routes to interconnect all sites, staging areas and U. S. supply points total 60,000 air-route miles, and when establishing the route of the present line, survey teams covered more than a million air miles and took over 80,000 photographs for analysis as part of the mapping activities.

Nature's Semiconductors

Two biologists of the Oak Ridge National Laboratory, William Arnold and Helen K. Sherwood, have reported finding in chloroplasts electrical and optical effects similar to those in semiconductors. Their work on the chlorophyll-containing bodies is described in an article, "Are Chloroplasts Semiconductors?" in the January, 1957, issue of the *Proceedings of the National Academy of Sciences.*

The studies of Arnold and Sherwood were based on work by Dr. Melvin Calvin of the University of California and others, who reasoned that since chloroplasts are built in layers of proteins, chlorophyll and fats analogous to the conductivity layers of semiconductor devices, similar photo-electric phenomena might be observed. Chloroplasts have been placed in a magnetic field and subjected to radio-frequency energy, and under these conditions free electrons were found in illuminated samples.

Arnold and Sherwood found that dried layers of chloroplasts absorb heat energy and re-radiate it as light energy, and that with increasing temperature, the electrical resistance of such layers decreases. Reports of the recent work at the U. of C. and Oak Ridge were published in the *Saturday Review* for April 6, 1957 and in the April 1957, issue of *Scientific American.*

The *Saturday Review* editorial, which points out that "a talented mind can sometimes penetrate the secrets of nature with uncanny precision," reviews the past history of semiconductor research and development at Bell Laboratories. Mention is made of the early work of R. S. Ohl, J. H. Scaff and others, and progress in this field is traced through the invention of the transistor and the Bell Solar Battery. "In short," the editorial concludes, "the fellows at Bell Labs had been so imaginative that they actually copied nature's method of capturing and using sunlight – years before any man understood how nature herself did the job!"

W. H. Doherty Named Assistant to President

W. H. Doherty, former Director of Research in Electrical Communications of the Laboratories and, since August, 1955, Assistant Vice President, Merchandising, at the American Telephone and Telegraph Company, has accepted the position of Assistant to President of Bell Telephone Laboratories, effective April 1, 1957.

W. H. DOHERTY

F. B. Llewellyn, who has been Assistant to President since October 1956, will continue in that capacity with primary responsibility for relations with foreign firms, particularly licensees of the Western Electric Company.

Mr. Doherty, who holds degrees from Harvard, joined the Laboratories in 1929, and at the Whippany, N. J., location took part in the development of high power radio transmitters for transoceanic service and broadcasting. Later he participated in pioneering work in the fire-control radar field, and throughout World War II supervised a development group which was responsible for the design of a number of radars that were widely used on naval surface ships and submarines for gunfire and torpedo control.

He continued in military electronics work until 1949, when he became Director of Electronic and Television Research. He holds an honorary doctorate from Catholic University, and was also awarded the Morris Liebmann Memorial Prize of the Institute of Radio Engineers. He was appointed Director of Research in Electrical Communications in 1952 and continued in that post until accepting his position with the American Telephone and Telegraph Company in 1955.

Hubert J. Horan, Jr., presents John Scott Medals to members of the Laboratories who invented the Bell Solar Battery. Left to right, C. S. Fuller, Mr. Horan, G. L. Pearson and D. M. Chapin.

John Scott Medals Awarded to Inventors of Bell Solar Battery

Daryl M. Chapin, Calvin S. Fuller and Gerald L. Pearson, members of the technical staff of Bell Telephone Laboratories, have been awarded John Scott Medals for their invention of the Bell Solar Battery. The medals, accompanied by a premium of $2,000 divided equally among the three recipients, was presented to Drs. Fuller, Pearson and Chapin at a meeting of the Franklin Institute in Philadelphia on March 20. The medals were presented by Hubert J. Horan, Jr., president of the Broad Street Trust Company of Philadelphia and a member of the Board of Directors of City Trusts of the City of Philadelphia, which administers the award.

The medal is named for John Scott, a chemist of Edinburgh, Scotland, whose will in 1816 established the award and entrusted its administration to the City of Philadelphia. He instructed that it be given to "ingenious men and women who make useful inventions" and that the bronze medal be inscribed "To the most deserving."

During its 141-year history the John Scott Medal has been awarded to more than 500 men and women of many nationalities. Included among the recipients have been Orville Wright, Thomas A. Edison, Madame Curie, Guglielmo Marconi, Lee de Forest, Dr. Irving Langmuir, and Dr. Vannevar Bush. In addition to the Solar Battery inventors, previous Laboratories award winners include William G. Housekeeper, Gustaf W. Elmen, Herbert E. Ives, Robert R. Williams, Harold B. Arnold, Walter H. Brattain and John Bardeen.

Laboratories Announces Winners of Graduate Fellowships

Bell Telephone Laboratories announced on April 7 the names of twenty recipients of its 1957-58 college fellowships. Established in 1955, the grants go to outstanding students pursuing graduate studies leading to Ph.D. degrees in engineering and physical sciences. Each fellowship carries a grant of $2,000 to the fellow and an additional $2,000 to cover tuition, fees and other costs of the institution where he elects to study.

Recipients of the fellowships may choose for study any one of the various branches of mathematics, physics, chemistry and engineering. Eight of the winners this year will do advanced study in electrical engineering. Physics is the chosen field for four, physical chemistry for three, and three are graduate mathematics students. One is studying engineering mechanics and another mathematical physics. The twenty winners will study at sixteen universities across the country.

Awards are made on recommendation of the Laboratories Fellowship Committee in collaboration with the faculties of the graduate schools. The Committee consists of H. A. Affel, R. L. Dietzold, K. E. Gould, J. A. Hornbeck, S. B. Ingram, W. D. Lewis, M. B. Long, B. McMillan, H. E. Mendenhall and S. Millman.

In 1956, the first year the grants were awarded, fifteen fellows were named. For 1957 the number of awards has been increased to twenty. This year's group includes four previous recipients who are completing their work for Doctor of Philosophy degrees. They are: Daniel G. Dow, Palo Alto, Calif., Stanford University; Harold R. Leland, Wausau, Wis., University of Wisconsin; James E. Mercereau, Pasadena, Calif., California Institute of Technology; and Irwin W. Sandberg, Brooklyn, N. Y., Polytechnic Institute of Brooklyn.

Other fellowship winners, their home towns, and the colleges where they will study are: Bill R. Baker, Eldon, Iowa, Stanford University; Phillip A. Bello, Mattapan, Mass., Massachusetts Institute of Technology; William B. Bridges, Inglewood, Calif., University of California; Hsu Chang, Taipei, Formosa, Carnegie Institute of Technology; Norman R. Draper, Southampton, England, University of North Carolina; Donald R. Fredkin, New York City, Princeton University; Sivert H. Glarum, Wyncote, Pa., Brown University.

William H. Jones, Jr., Newark, Del., University of Delaware; William L. Kilmer, Wellsboro, Pa., Uni-

versity of Michigan; Kenneth L. Kotzebue, San Antonio, Tex., Stanford University, Eugene Levine, Brooklyn, N. Y., New York University; Bede Liu, New York City, Polytechnic Institute of Brooklyn; James McKenna, Lebanon, N. H., Princeton University; Werner A. W. Mehlhop, Hamburg, Germany, Washington University at St. Louis, Mo.; William H. Orttung, Narberth, Pa., University of California; and Sukeyasu Yamamoto, Tokyo, Japan, Yale University.

Laboratories Committee Aids Planning for High School Physics Teaching

Several members of the Laboratories are participating with similar groups at the Massachusetts Institute of Technology, the University of Illinois and Cornel University in planning a new approach to teaching of physical science in high schools.

The combined groups form a Physical Science Study Committee sponsored by the National Science Foundation. J. R. Zacharias, Professor of Physics at M.I.T., is Chairman of the full committee, and of the steering committee located at M.I.T.

At an early meeting of the combined groups held in Cambridge last December, the broad outline of a completely new physics course was adopted.* This new approach includes four general topics: the structure of the universe, light and waves, mechanics, and atomic theory. Other topics covered in the present-day physics curriculum will be described in a series of monographs. The program is aimed at approximately twenty-five per cent of the student population in high school. It was agreed that the purpose would be "to build a good scientific background in a section of the population (which it is hoped will later increase in size) and to develop a course in physics which emphasizes the essential intellectual, aesthetic, and historical background." The general organization is designed to give the student a better understanding of physics and its underlying unity by directing all the subject matter toward the atomic picture of the universe. The coherence and power of physical ideas in certain narrower fields will be explored in depth.

Members of the various subgroups are now preparing expanded treatments of various parts of the broad subject outline adopted at the December meeting. W. P. Slichter of the Laboratories Chemical Research Department is working on a section dealing with the structure of matter, and J. N. Shive of the Personnel Department (formerly of the Solid State Device Development Department) is working on a section devoted to wave motion.

Present plans call for a collection of visual aids such as movies and sound-filmstrips to be used as an integral part of a one-year course. In this connection, A. N. Holden of the Physical Research Department and W. D. Bulloch of the Publication Department prepared a sample sound-filmstrip on the refraction of light for the December meeting. The technique was favorably received by the full group. A modified version is now in preparation by R. O. Grisdale and F. G. Foster of the Laboratories.

Members of the Laboratories currently active in the local committee include: S. Millman, Chairman, W. D. Bulloch, R. O. Grisdale, A. N. Holden, J. J. Lander, H. O. Pollak, J. N. Shive, W. P. Slichter and P. A. Wolff. This group will welcome comments from others in the Laboratories interested in secondary school education.

* A brief report of this conference was published in the March, 1957, issue of *Physics Today*.

Laboratories Receives Award from U. S. Information Agency

The Laboratories has received a Certificate of Merit from the United States Information Agency for its part in the Agency's "Space Unlimited" exhibit at the International Trade Fair held in Berlin, during September and October of 1956.

The Certificate, received by Laboratories Exhibit Supervisor Henry J. Kostkos, commends the Laboratories for "cooperating in projects designed to promote better understanding of the United States in other countries." The exhibit – which included demonstrations of the Laboratories Bell Solar Battery, miniaturized transistor circuits, printed wiring, and relay computer circuits – was seen by more than 200,000 people and is now on tour in Germany.

U. S. Information Agency Director Arthur Larson expressed his gratitude to Bell Telephone Laboratories for assisting in "carrying to the people of Europe President Eisenhower's message that 'an understanding of the truth about America is one of our most powerful forces.'"

Talks by Members of the Laboratories

During March, a number of Laboratories people gave talks before professional and educational groups. Following is a list of speakers, titles, and places of presentation.

I.R.E. National Convention, Waldorf-Astoria Hotel, New York City.

Kelly, J. L., Jr., *Coding a Continuous Information Source.*

Kuh, E. S., *Synthesis of R-C Grounded 2-Ports.*

Kuh, E. S., *Synthesis of Lumped Parameter Precision Delay Line.*

Myers, G. H., *A Cyclic Digital-to-Analog Decoder.*

Perry, A. D., Jr., *Pulse-Forming Networks Approximating Equal-Ripple Flat-Top Step Response.*

Pierce, J. R., *What Good Is Information Theory to Engineers?*

Stone, H. A., *Component Development for Microminiaturization.*

American Physical Society, University of Pennsylvania, Philadelphia, Pa.

Arrott, A., see Cooper, H. W.

Augustyniak, W. M., see Brown, W. L.

Backenstoss, G., *Conductivity Mobilities in Heavily Doped Silicon.*

Batterman, B. W., and Pfann, W. G., *Etch Hillocks on Germanium Single Crystals.*

Brown, W. L., and Augustyniak, W. M., *Orientation Dependence and Threshold Energy of Radiation Damage in Germanium.*

Chynoweth, A. G., and McKay, K. G., *Internal Field Emission in Silicon P-N Junctions.*

Cooper, H. W., Arrott, A., and Paxton, H. W., *Parasitic Ferromagnetism in a Manganese.*

Dillon, J. F., *Ferrimagnetic Resonance in Yttrium Iron Garnet (1/IG) Samples of Various Shapes.*

Galt, J. K., *Cyclotron Resonance Experiments in Metallic Bismuth and Graphite.*

Hagstrum, H. D., *Valence Band Structure of Silicon.*

Kunzler, J. E., and Renton, C. A., *The "Size Effect" in Electrical Resistivity Measurements on Single Crystals of Very Pure Tin at Liquid Helium Temperatures.*

Lax, M., *Optical Phonon Contribution to Cascade Capture.*

McCall, D. W., *Diffusion in Ethylene Polymers. Desorption Kinetics From a Thin Slab.*

McCall, D. W., see Slichter, W. P.

McKay, K. G., see Chynoweth, A. G.

Matthias, B. T., *Ferroelectricity in 1956.*

Morin, F. J., and Reiss, H., *Precipitation of Lithium in Germanium.*

Paxton, H. W., see Cooper, H. W.

Pfann, W. G., see Batterman, B. W.

Renton, C. A., see Kunzler, J. E.

Scovil, H. E. D., *The Design and Performance of a Solid State Maser.*

Shulman, R. G., *Nuclear Magnetic Resonance in Iron Group Fluorides.*

Slichter, W. P., and McCall, *Molecular Motion in Polyethylene.*

Van Roosbroeck, W., *The Effect of Traps on Current Carrier Transport in Semiconductor.*

Waite, T. R., *Theory of Diffusion Limited Reactions; Annealing of Radiation Damage in Ge.*

Wheatley, G. H., see Whelan, J. M.

Whelan, J. M., and Wheatley, G. H., *Preparation of GaAs Single Crystals.*

Other Talks

Beck, A. C., *Waveguides for Long Distance Communication,* Lavoie Laboratories, Keyport, N. J.

Benes, V. E., *A Note on Fluctuations of Telephone Traffic,* Institute of Mathematical Statistics, Washington, D. C.

Benes, V. E., *A Sufficient Set of Statistics for the Parameters of a Simple Telephone Exchange Model,* Institute of Mathematical Statistics, Washington, D. C.

Biondi, F. J., *Status of Transistor Technology,* Plant Supervisors' Club, Chesapeake and Potomac Telephone Companies, Hotel Belvedere, Baltimore, Md.

Boyd, R. C., *Systems Engineering at Bell Telephone Laboratories — The Type P1 Rural Subscriber Carrier System,* Joint Student Branch, A.I.E.E.-I.R.E., University of Toledo, Toledo, Ohio.

Campbell, M. E., *Transatlantic Cable System,* Boonton Rotary Club, Boonton, N. J.

Compton, K. G., *Electrical Measurements and Their Interpretation in Underground Cable Corrosion Problems,* National Association of Corrosion Engineers Annual Conference, St. Louis, Mo.

Dodge, H. F., *The Statistical Approach to Quality Engineering,* Annual Convention of the Technical Societies of New Jersey, Newark, N. J.

Fleckenstein, W. D., *Trends in Communication Systems,* Joint I.R.E.-A.I.E.E. Student Group, City College of New York, New York City.

Frisch, H. L., *Diffusion in Polymers,* State University of New York, College of Forestry, Syracuse, N. Y.

Garrett, C. G. B., *Semiconductors and Surfaces,* Physics Colloquium, Bryn Mawr, Bryn Mawr, Pa.

Gerdsen, W. D., *Bell Solar Battery,* Kiwanis Club, Bloomfield, N. J.

Gerdsen, W. D., *Bell Solar Battery,* Boy Scout Group 8, Plainfield, N. J.

Goehmer, W. R., see Peters, H.

Gupta, S. S., and Sobel, M., *On Selecting a Subset Which Contains all Populations Better Than a Standard,* Meeting of the Institute of Mathematical Statistics, Washington, D. C.

Harvey, F. K., *The Physics of Hearing and Music*, A.I.E.E.-Hi-Fi Series, New York City.

Harvey, F. K., *Speech, Hearing and Music*, Merrimack Valley Subsection A.I.E.E., North Andover, Mass.

Hopkins, I. L., *Complex Stress-Strain Relations in Polyethylene*, Polytechnic Institute of Brooklyn.

Kramer, H. P., *Perturbation of Differential Operators*, Mathematics Colloquium, Stevens Institute of Technology, Hoboken, N. J.

Krusemeyer, H. J., and Thomas, D. G., *Adsorption and Charge Transfer on Semiconductor Surfaces*, Conference on Physical Electronics, Massachusetts Institute of Technology, Cambridge, Mass.

Lander, J. J., *Solubility of Hydrogen and Semiconductivity in ZnO Under Hydrogen Ion Bombardment*, Electronics Conference, Massachusetts Institute of Technology, Cambridge, Mass.

Liehr, A. D., *On the Use of the Born-Oppenheimer Approximation in Molecular Problems*, American Physical Society, University of Oklahoma, Norman, Oklahoma.

Lockwood, W. H., see Peters, H.

Mardis, T. E., *Science or Fiction*, Rotary Club, Winston-Salem, N. C.

McDonald, H. S., *Perfection and Coding of Auditory Information*, Graduate Electrical Engineering Seminar, Polytechnic Institute of Brooklyn.

Peters, H., Goehmer, W. R., and Lockwood, W. H., *Magnetic Elastomers for Telephone Answering Devices*, New York Rubber Group, Henry Hudson Hotel, New York City.

Pfann, W. G., *Recent Developments in Zone Melting*, Senior Staff Seminar, Carnegie Institute of Technology, Pittsburgh, Pa.

Pierce, J. R., *Fancies and Fallacies of Space Travel*, Northern New Jersey Section I.R.E., Upper Montclair, N. J.

Read, W. T., *Dislocations in Semiconductors*, Physics Colloquium, Brown University, Providence, R. I.

Rowe, H. E., *Information Theory*, Chicago Section, A.I.E.E., Chicago, Ill.

Shulman, R. G., *Nuclear Magnetic Resonance in Semiconductors*, International Business Machines, Watson Laboratorp, New York City.

Sobel, M., see Gupta, S. S.

Stanton, C. I., and Van Wynen, K. G., *Communications and Movement of Air Traffic in the Air Route Traffic Control System*, A.I.E.E., Communications Division, New York City.

Storks, K. H., *Spectroscopy in the Analysis of Materials*, Amateur Astronomical Society Meeting, Roselle Park, N. J.

Sullivan, M. V., *Bell Solar Battery*, Electrochemical Society, Boston, Mass.

Terry, M. E., *The Sech Squared Distribution*, Metropolitan Section, American Standards Association, New York City.

Thomas, D. G., see Krusemeyer, H. J.

Thurston, M. O., *Diffusion in Semiconductors*, Metallurgical Symposium, Ohio State University, Columbus, Ohio.

Van Wynen, K. G., see Stanton, C. I.

Patents Issued to Members of Bell Telephone Laboratories During February

Breed, R. N., Groth, W. B., Irwin, G. C., Kille, L. A., and Riggs, G. – *Tape-to-Card Converter Circuit* – 2,780,-410.

Brewer, S. T. – *Supervisory Circuit* – 2,783,307.

Chapin, D. M., Fuller, C. S., Pearson, G. L. – *Solar Energy Converting Apparatus* – 2,790,765.

Dimond, T. L. – *Calling Subscriber Identifier Using Transistor Oscillator in Subsets* – 2,782,259.

Fuller, C. S., see Chapin, D. M.

Gamble, G. L., and Jakus, L. A. – *Coaxial Noise Diode* – 2,782,341.

Grant, D. W. – *Magnetic Amplifier Circuits* – 2,782,269.

Groth, W. B., see Breed, R. N.

Irwin, G. C., see Breed, R. N.

Jakus, L. A., see Gamble, G. L.

Kille, L. A., see Breed, R. N.

Madden, J. J., and Sumner, E. E. – *Punch Selector* – 2,781,846.

Malthaner, W. A. – *Timing Circuits* – 2,782,256.

Marrison, W. A. – *High Precision Frequency Standards* – 2,782,313.

Miller, W. F. – *Frequency Supply Circuits for Carrier Systems* – 2,782,314.

Pearson, G. L., see Chapin, D. M.

Pollard, C. E., Jr. – *Power Control Circuit* – 2,781,459.

Riggs, G., see Breed, R. N.

Sumner, E. E., see Madden, J. J.

Vibbard, E. L. – *Tape Control Arrangement for Computer* – 2,782,985.

Wall, V. W. – *Visual Indicator of Harmonic Distortion* – 2,782,366.

Wilhelm, H. T. – *Impedance Measuring Means* – 2,783,435.

Papers Published by Members of the Laboratories

Following is a list of the authors, titles, and places of publication of recent papers published by members of the Laboratories:

Burns, F. P., *Piezoresistive Semiconductor Microphone*, J. Acous. Soc. Am., **27**, pp. 248-253, Feb., 1957.

Dowling, R. C., *Lightning Protection on the Stevens Point-Wisconsin Rapids Intercity Telephone Cable*, Commun. and Electronics, **28**, pp. 697-701, Jan., 1957.

Feher, G., *Electronic Structure of F Centers in KCl by the Electron Spin Double-Resistance Technique*, Phys. Rev., Letter to the Editor, **105**, pp. 1122-1123, Feb. 1, 1957.

Geballe, T. H., Carruthers, J. A., Rosenberg, H. M., and Ziman, J. M., *The Thermal Conductivity of Germanium and Silicon Between 2 and 300°K*, Proc. Royal Soc., **A238**, pp. 502-514, Jan. 29, 1957.

Geller, S., and Gilleo, M. A., *Structure and Ferrimagnetism of Ythium and Rare-Earth – Iron Garnets*, Acta Crys., **10**, p. 239, March 10, 1957.

Gilleo, M. A., *Crystallographic Studies of Perovskite-Like Compounds, III La(M_x, Mn_{1-x})0 with M = Co, Fe and Cr*, **10**, pp. 161-166, March, 1957.

Gilleo, M. A., see Geller, S.

Green, E. I., *Nature's Pulses*, I.R.E. Student Quarterly, **3**, pp. 3-5, Feb., 1957.

Hagstrum, H. D., *Thermionic Constants and Sorption Properties of Hafnium*, J. Appl., Phys., **28**, pp. 323-328, March, 1957.

Haworth, F. E., *Breakdown Fields of Activated Electrical Contacts*, J. Appl. Phys., Letter to the Editor, **28**, p. 381, March, 1957.

Joel, A. E., *Electronics in Telephone Switching Systems*, Commun. and Electronics, **28**, pp. 701-709, Jan., 1957.

Karlin, J. E., see Pierce, J. R.

Law, J. T., and Meigs, P. S., *The High Temperature Oxidation of Germanium, Semiconductor Surface Physics* (book), pp. 383-400, 1957, Univ. of Penna. Press, Philadelphia.

McCall, D. W., *Nuclear Magnetic Resonance in Guanidinium Aluminum Sulfate Hexahydrate*, J. Chem. Phys., Letter to the Editor, **26**, pp. 706-707, March, 1957.

Meigs, P. S., see Law, J. T.

Mendizza, A., Sample, C. H., and Teel, R. B., *A Comparison of the Corrosion Behavior and Protective Value of Electrodeposited Zinc and Cadmium on Steel*, Symposium on Properties, Tests, and Performances of Electrodeposited Metallic Coatings, A.S.T.M. Special Tech. Publication **197**, pp. 49-64, 1957.

Miller, S. L., *The Ionization Rates for Holes and Electrons in Si*, Phys. Rev., **105**, pp. 1246-1249, Feb. 15, 1957.

Pierce, J. R., and Karlin, J. E., *Information Rate of a Human Channel*, Proc. I.R.E., Letter to the Editor, **45**, p. 368, March, 1957.

Rea, W. T., *The Communication Engineer's Needs in Information Theory*, Commun. and Electronics, **28**, pp. 805-808, Jan., 1957.

Treuting, R. G., *Torsional Strain and the Screw Dislocation in Whisker Crystals*, Acta Met., Letter to the Editor, **5**, pp. 173-175, March, 1957.

Van Uitert, L. G., *Magnesium-Copper-Manganese-Aluminum Ferrites for Microwave Applications*, J. Appl. Phys., **28**, pp. 320-322, March, 1957.

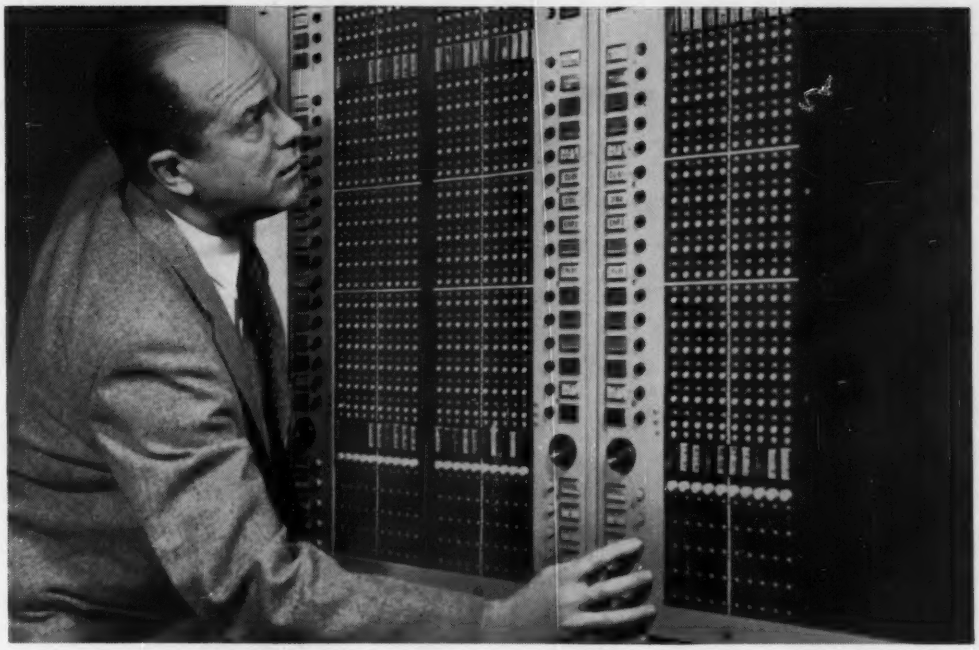
Van Uitert, L. G., *Magnetic Induction and Coercive Force Data on Members of the Series $BaAl_xFe_{12-x}O_{19}$ and Related Oxides*, J. Appl., Phys., **28**, pp. 317-319, March, 1957.

Walker, L. R., *Orthogonality Relation for Gyrotropic Wave Guides*, J. Appl. Phys., Letter to the Editor, **28**, p. 377, March, 1957.

Weber, L. A., *Influence of Noise on Telephone Signaling Circuit Performance*, Commun. and Electronics, **28**, pp. 636-643, Jan., 1957.

Weiss, J. A., *An Interference Effect Associated with Faraday Rotation and Its Application to Microwave Switching*, Proc. Conf. on Magnetism and Magnetic Materials, pp. 580-585, Feb., 1957.

Younker, E. L., *A Transistor Driven Magnetic Core Memory*, Trans. I.R.E. **PGEC, EC-6**, pp. 14-20, March, 1957.



Bell Laboratories engineer Cyril A. Collins, B.S. in EE., University of Washington, demonstrates new TV switching control panel for black and white or color. Complex switching connections are set up in advance; in a split second a master button speeds dozens of programs to their destinations all over the nation. Special constant-impedance technique permits interconnection of any number of broadband circuits without picture impairment.

Telephone science speeds TV enjoyment

Telephone science plays a crucial part in your TV entertainment. An interesting example—one of many—is the latest TV switching center developed at Bell Laboratories.

Switching centers control the transmission of programs which come to your local TV station over Bell System facilities. To be available exactly on cue, programs must be switched at high speed and with very great accuracy.

To create the new switching center Bell Laboratories engineers borrowed from the switching control art which handles your dial telephone calls. They developed a special control panel which puts complex switching patterns within the easy grasp of one man. By pushing buttons, he sets up—and double-checks—forthcoming network changes far ahead of time. On cue he presses a master button which sends the programs racing to their respective destinations around the nation.

To connect the broadband circuits, the Laboratories engineers developed a new video switch which operates on a constant-impedance principle. The new switch permits the interconnection of any number of circuits, without the slightest impairment of transmission quality.

Thus the technology which serves your telephone also works for your TV enjoyment.

BELL TELEPHONE LABORATORIES

World center of communications research and development

Bell Laboratories RECORD